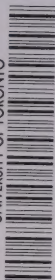


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The Evolution of the Periodontal Pus-Pocket

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TORONTO



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Bulletin Number One

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The Evolution of the Periodontal Pus-Pocket

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ULCERATIVE pockets overlying cementum may be defined as the lesions produced by the establishment of infection in the cemental gingivae and pericementum, whereby, through suppurative process, these tissues have been detached from the cementum. Dependant upon the amount and nature of the loss of tissue, ulcerative pockets may be classified into two main groups—the first, in which the lesion is confined to the cemental gingiva, and the second, in which extension of the ulcerative process has taken place into the pericementum. An understanding of pocket formation in dental periclasia is impossible without an adequate conception of the histological complex in which the pathological changes are initiated. The importance of the gingivae in their relationship to the pericementum, both in health and disease, necessitates the following short description of their minute anatomy.

The tissues of the oral cavity known as the gingivae include all the soft tissues which invest the cervical portions of the crowns and roots of the teeth, to the level of the crests of the alveolar process. The main bulk of the gingival tissue rests upon the crests of the alveolar process, and is supported by them. From these crests to the gingival line, the amelo-cemental junction, and attached to the cementum, is that division of these tissues known as the cemental gingivae. The cemental gingivae are attached to the alveolar crests by fibres of the periosteum and certain principal fibres which are inserted in the cementum.

Rising from the cemental gingivae and supported by them are wedge-shaped tissue extensions which encircle the enamel at the cervix. These are known as the marginal gingivae. By their contact with

the enamel they form the so-called gingival crevice, the deepest portion of which is bounded by the first attachment of the cemental gingivae at the amelo-cemental junction.

The epithelium which covers the gingivae is of the stratified squamous type, and rests on a thin basement membrane. It differs from that of the gums, the tissue of which is continuous with the cemental gingiva and which covers the alveolar process, in that it becomes thicker and stronger progressively from a point approximately opposite the crest of the alveolar process to the crest of the marginal gingiva. A characteristic of the gingivae is the invagination into the epithelium of finger-like papillae of connective tissue. The distribution of the epithelium on the crevicular* surface of the marginal gingiva is an outstanding feature, because, as a rule, it is unusually thin. Occasionally breaks can be noticed in this lining, where the epithelium is absent, and again, imperfect junctions of the crevicular epithelium with the cementum are frequently observed. These facts—its extreme thinness, the possible presence of breaks on the surface, and imperfect junctions, render this crevicular surface the weakest link in the chain of epithelial covering in the mouth.

The gingivae have an extremely rich blood supply, which is derived from the pericemental and periosteal blood-vessels, as well as those of the adjoining gums. The connective tissue of each papilla carries an arteriole which passes to its extremity, where it terminates in a capillary loop and returns as a vein. This circulatory apparatus is designed to carry nourishment to all the epithelial cells. It is commonly seen in the microscopic study of these tissues, that the cells separating the capillary loops from the saliva are very few in number.

The progression of the inflammatory process in the evolution of a pus-pocket may be classified into the following four stages:

1. Early inflammatory reaction following the initial invasion of bacteria.
2. Loss of some of the epithelial lining at the extremity of the gingival crevice, and the establishment of ulceration in the cemental gingiva.
3. Progressive loss of tissue, and the formation of a pocket in the cemental gingiva.
4. Extension of the pocket into the pericementum.

Bacterial invasion of the gingivae, in practically all cases except the phagedenic type, takes place from the gingival crevice through the crevicular surface of the marginal gingiva. A microscopic examination of a large number of early lesions in the gingivae has demonstrated to the essayist that the great majority of infections occur at the base of the gingival crevice, where, through imperfect junction of the epithelial cells with the cementum, or because of the extreme thinness of this defensive covering, the tissue underlying this

*Crevicular: Adjective—relating to the gingival crevice



FIG. NO. 1.

In Fig. No. 1 is shown the gingival crevice and the attachment of the marginal gingiva to the tooth. Note the extremely thin protective covering of stratified squamous epithelium on the crevicular surface of the marginal gingiva.

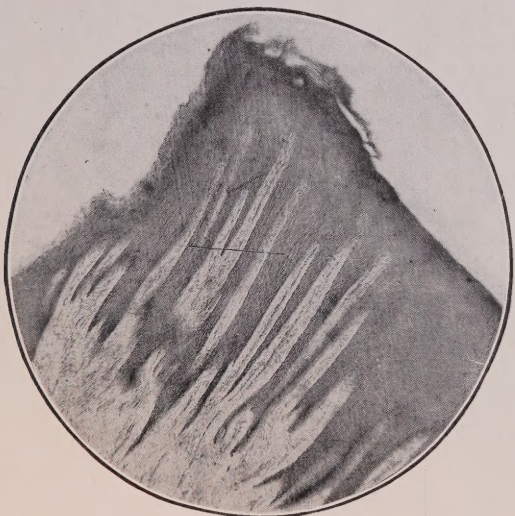


FIG. NO. 2.

In Fig No. 2, showing the marginal gingiva, note the extremely thick covering of epithelium on the outer surface. Into this epithelium are projected long finger-like extensions of the underlying connective tissue.

area is not adequately protected. The earliest lesion which occurs following bacterial invasion is a minute area of small cell infiltration, the inflammatory reaction to the micro-organisms. Leucocytes escape from this area through the thin layer of epithelium, and appear, along with desquamated epithelial cells, on the crevicular surface of the marginal gingiva.

When, through progression of the inflammatory process, ulceration has been established at the base of the gingival crevice, after the necrotic epithelium is cast off, the attachment of the principal fibres of the cemental gingiva, at the gingival line, is involved. Due to the action of ferments liberated, either by the polymorphonuclear leucocytes or by bacteria, tissue solution takes place, resulting in the stripping of gingival tissue from the cementum and the formation of a small pocket. Penetration of this pocket into the deeper tissues, following further bacterial invasion, results in the complete loss of attachment of the cemental gingiva to the cementum, and in the establishment of ulceration and pocket formation in the pericementum. The soft tissues covering the denuded cementum present a surface which is in a state of constant inflammatory reaction. This varies within wide limits, depending upon the amount and nature of the injurious agents and on the severity and character of the injury. The cementum underlying the pocket and from which the soft tissues have been detached, always presents a septic surface. This is due to the frequency of serum deposits and to the retained ends of the principal fibres in the insertion layer.

The type of exudation from periodontal pockets is commonly known as pus, and is made up of leucocytes in abundance, serum in varying quantities, fibrin usually of scant amount, and living and dead bacteria. Of the leucocytes, the polymorphonuclear predominates, although endothelial leucocytes and lymphocytes may be fairly abundant.

It must not be overlooked that when a pus-pocket is present in the pericementum, it is usually but a part of a more involved pathological complex. While the stages in the histo-pathology of the actual pus-pocket are essentially the same in all cases, the formation of a pus-pocket in the pericementum is a phenomenon preceded in many cases by much more complicated and deeper changes than simple gingivitis. The ideal requisites for rapid and deep pocket extension are alveolar resorption, lowered resistance in all or part of the pericementum, and gingivitis. Lowered resistance in the pericementum is frequently brought about by excessive mechanical function of the teeth or, upon the other hand, by their disuse.

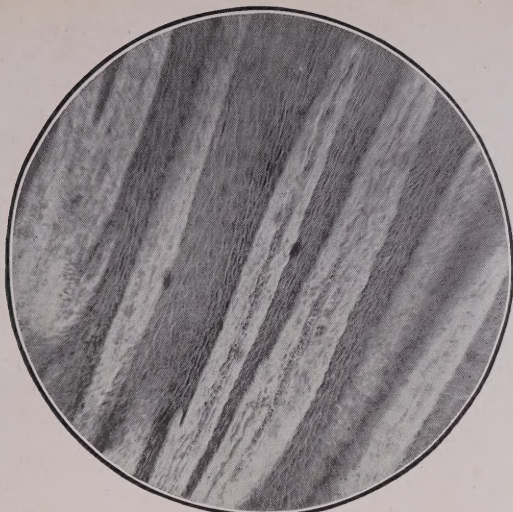


FIG. NO. 3.

Fig. No. 3 is a high magnification of the connective tissue extensions into the epithelium. Each papilla supports a circulatory system comprising an arteriole, capillary loop, and returning vein. The blood is carried by the arteriole to the end of the connective tissue papilla, passing there through the capillary into the returning vein.

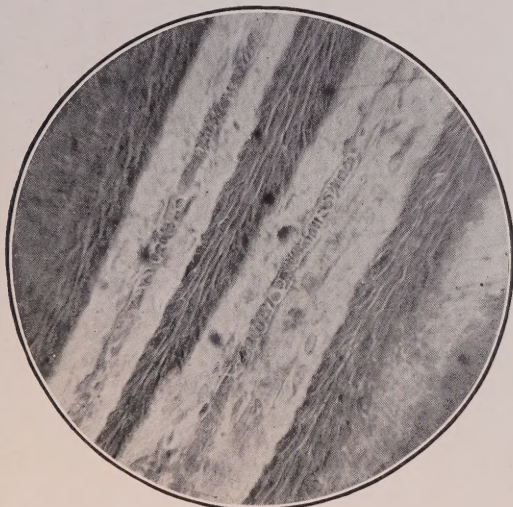


FIG. NO. 4.

Fig No. 4 is a very high magnification of two connective tissue papillae. In one, may be seen quite distinctly, the arteriole and returning vein lying side by side.

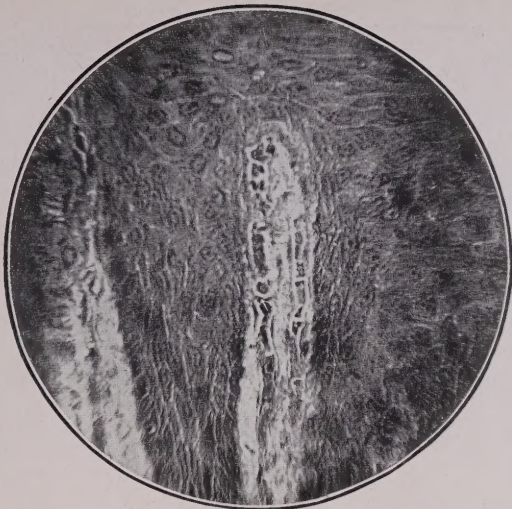


FIG. NO. 5.

Fig. No. 5 is a good example of a high magnification of the capillary loop at the extremity of one of the connective tissue papillae. The bulk of the tissue shown in this slide is made up of epithelial cells.

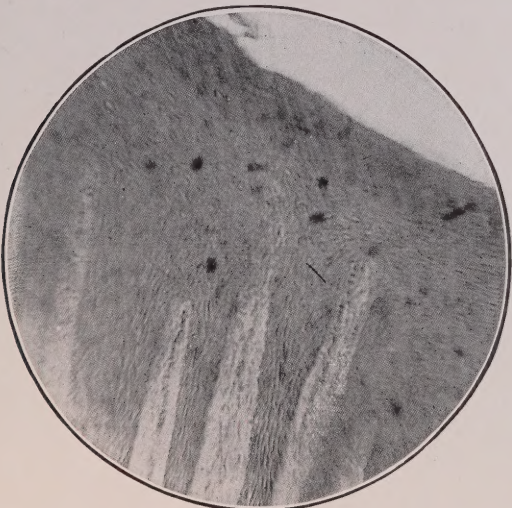


FIG. NO. 6.

Fig. No. 6 shows the very thin layer of epithelium which covers the capillary loops and protects the blood-stream from the oral fluids. This arrangement, which is ideal from the standpoint of nourishment of the epithelium, becomes a weakness in certain infective processes, evidenced in phagedenic gingivitis, and accounts, in part, for the rapid extension of ulceration.

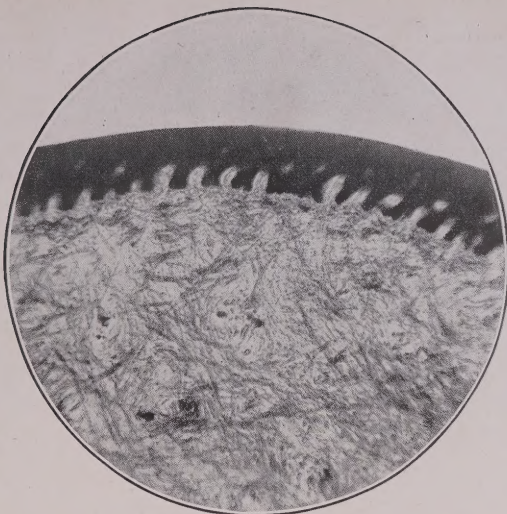


FIG. NO. 7.

Fig. No. 7.—That division of the soft tissues overlying the alveolar process to its crest is known as the gums. Fig. No. 7 demonstrates the interlaced mat of connective tissue fibres which holds this tissue to the process.

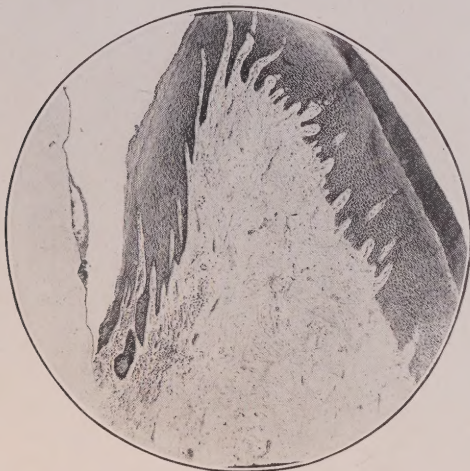


FIG. NO. 8.

Fig. No. 8.—Infection of the gingivae, as a rule, takes place at the extremity of the gingival crevice. A defective junction of the epithelium on the crevicular surface of the marginal gingival with the tooth, creates an easy avenue for bacterial invasion at this point. In Fig. 8, there is shown an example of an imperfect junction of the epithelium with the tooth.



FIG. NO. 9.

Fig. No. 9.—Occasionally, besides the weaknesses of the gingivae to infection, just described, viz., an extremely thin epithelial covering on the crevicular surface, and an imperfect junction, a third one is noted. In this class, breaks in the crevicular epithelium are found, in which the underlying connective tissue is devoid of epithelial protection. Two such breaks may be seen in Fig. No. 9.

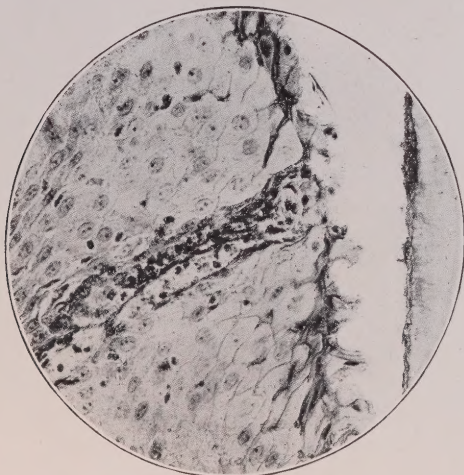


FIG. NO. 10.

Fig. No. 10.—This figure is a very high magnification of one of the breaks described in Fig. No. 9. Note the blood-vessel extending almost to the gingival crevice. Clumps of bacteria on the tooth surface just opposite are demonstrated.

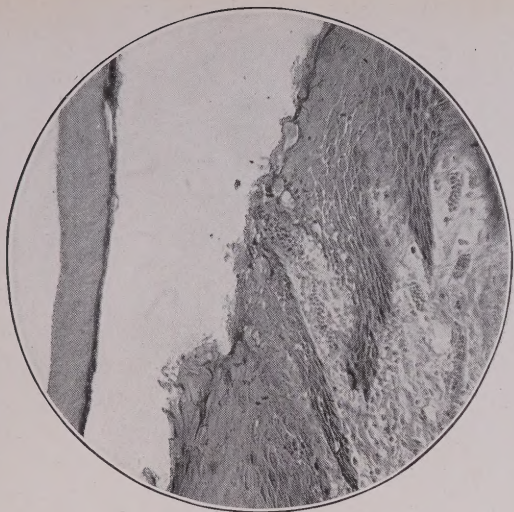


FIG. NO. 11.

Fig. No. 11.—In Fig. No. 11, another such break in the epithelial covering is evidenced. Again, note the blood-vessel passing to the gingival crevice.

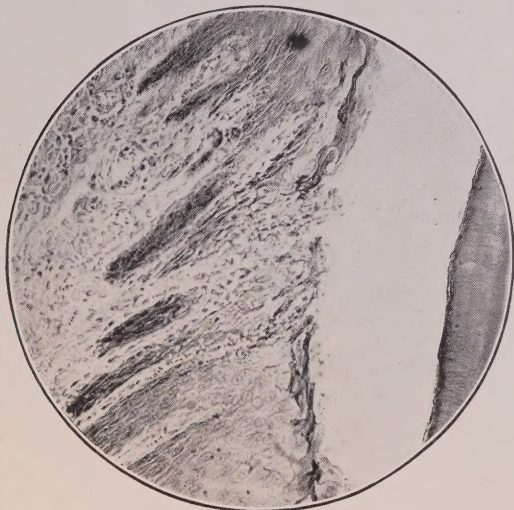


FIG. NO. 12.

Fig. No. 12.—Several breaks are shown in Fig. No. 12. Such histological defects must, in certain cases, be regarded as factors in gingival infection.

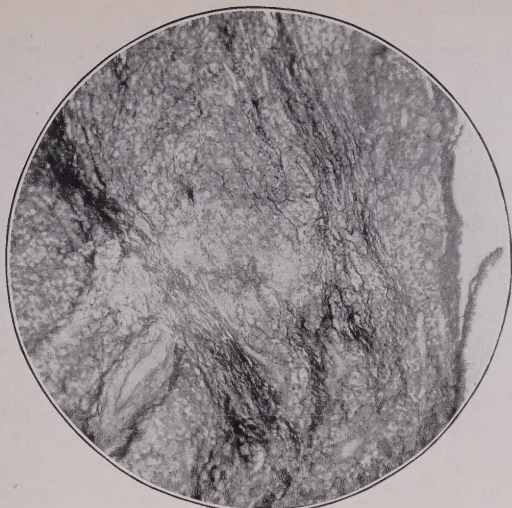


FIG. NO. 13.

Fig No. 13.—In the marginal gingiva is found the first group of principal fibres having their insertion in the cementum. They pass outward from the cementum and extend toward the crest of the marginal gingiva. The function of this group is to hold the marginal gingiva in close apposition with the enamel surface. This grouping of fibres is demonstrated in Fig. No. 13.

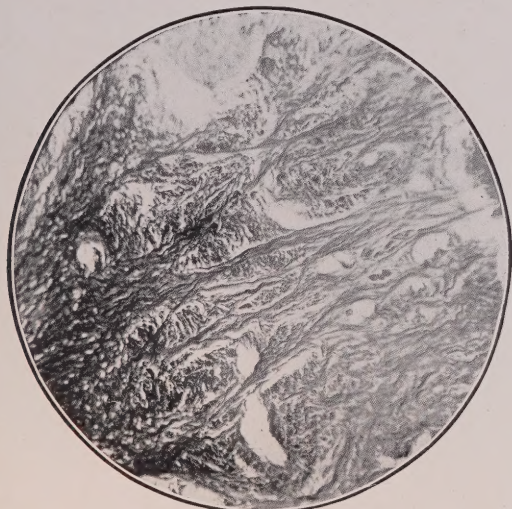


FIG. NO. 14.

Fig. No. 14.—In Fig. No. 14, is shown the second group of principal fibres, which passes mesio-distally from tooth to tooth through the cemental gingiva. It helps to hold the contact points of the teeth together, and is known as the "trans-septal" group.



FIG. NO. 15.

Fig. No. 15.—Next in order, is found a large, well-defined grouping of fibres, which originates in the cementum and passes to its attachment in the crest of the alveolar process. It is termed the "alveolar crest" group, and serves to prevent rotation of the tooth in its alveolus. In Fig. No. 15, this group is sharply defined. Note the line of demarcation between the dentine and the cementum, where, in the preparation of the section, the cementum has been separated from the dentine.



FIG. NO. 16.

Fig. No. 16 is a higher magnification of the same group, and shows in detail, the courses of its many fibres.

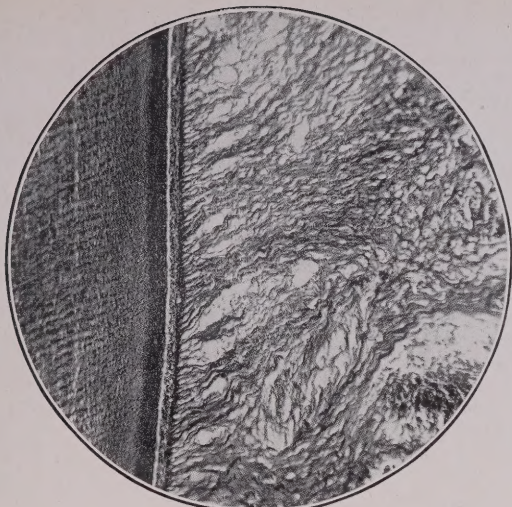


FIG. NO. 17.

Fig. No. 17.—Apical to the “alveolar crest” group, are found the “horizontal” and “oblique” groups, which pass from the cementum to the wall of the alveolar process. The “oblique” group is by far the larger, and constitutes the bulk of the pericementum. The fibres, from their attachment to the process, pass in a slightly apical direction to the tooth. This grouping is shown in Fig. No. 17.

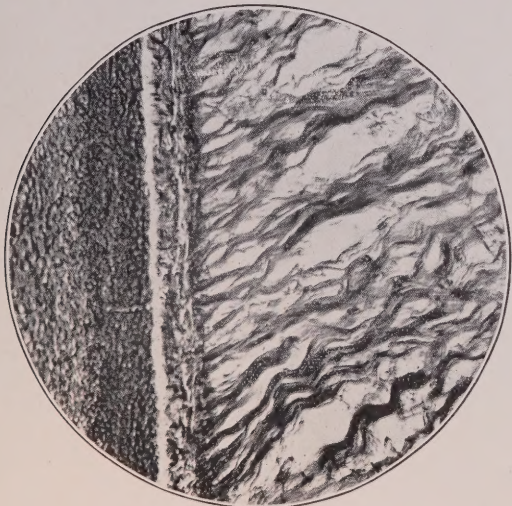


FIG. NO. 18.

In Fig No. 18 these fibres are shown highly magnified. Their function is to support the tooth during occlusal strain.

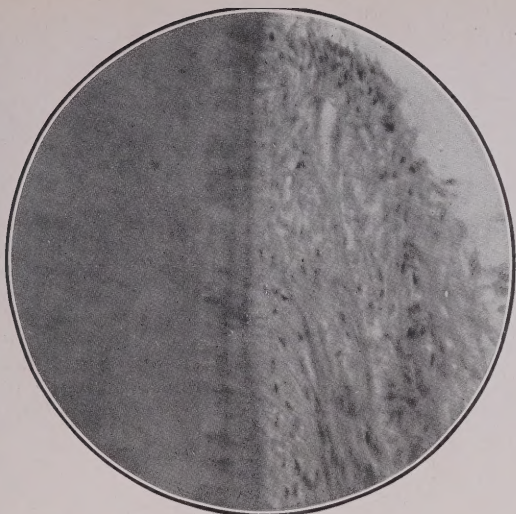


FIG. NO. 19.

Fig No. 19 demonstrates the insertion of the principal fibres of the gingivae and pericementum into the cementum. The cementum, upon the loss of the principal fibres in pocket formation, presents a pitted surface which affords an ideal lodging place for bacteria and their products.

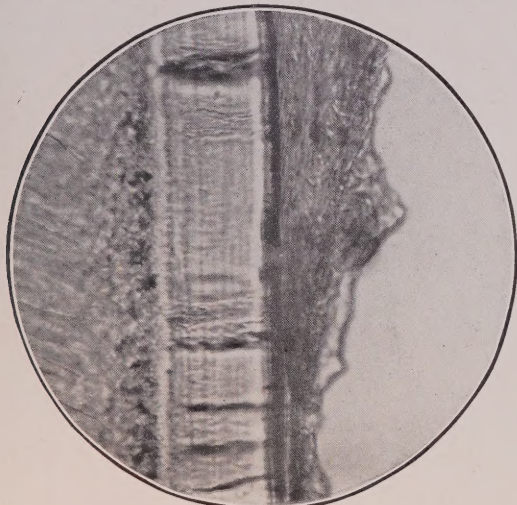


FIG. NO. 20.

Fig. No. 20.—The cementum underlying the average pus-pocket is practically homogeneous. It differs from the apical cementum in that it usually contains no cement corpuscles. It is extremely thin, from a clinical standpoint, and in many cases is about the same thickness as a human scalp hair. In Fig. No. 20, a section of this cementum with some attached pericementum is shown.

The progression of the inflammatory process in the evolution of a pus-pocket, may be classified into the following four stages: 1. Early inflammatory reaction following the initial invasion of bacteria. 2. Loss of some of the epithelial lining at the extremity of the gingival crevice, and the establishment of ulceration in the cemental gingiva. 3. Progressive loss of tissue, and the formation of a pocket in the cemental gingiva. 4. Extension of the pocket into the pericementum.

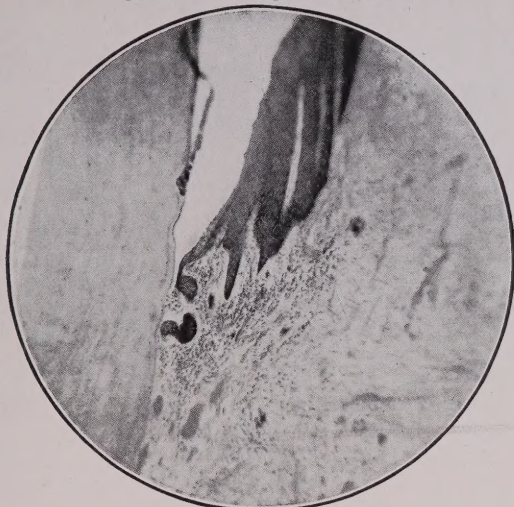


FIG. NO. 21.

Fig. No. 21.—Bacterial invasion of the gingivae, as a rule, takes place at the basal extremity of the gingival crevice. In Fig. No. 21, a faulty junction of the crevicular epithelium with the tooth is shown, and, in the gingival tissue immediately underlying it, may be noted a minute area of small cell infiltration, the inflammatory reaction to the invading micro-organisms. This is the earliest lesion which occurs in the evolution of a pus-pocket, and cannot be demonstrated clinically.

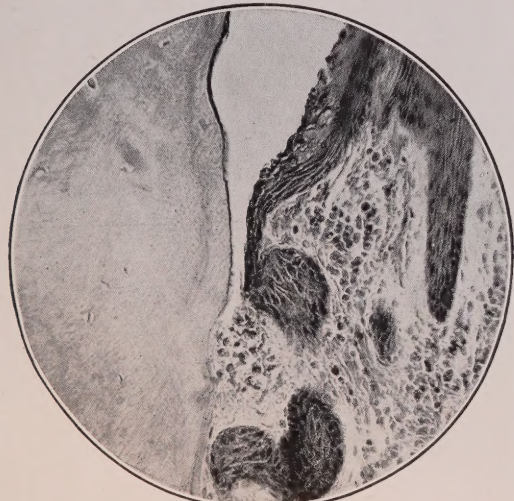


FIG. NO. 22.

Fig. No. 22.—In Fig. No. 22 a higher magnification of the foregoing lesion is shown. The imperfection of the junction of the epithelium with the tooth is plainly evidenced. The infiltration is of the plasma cell type.



FIG. NO. 23.

Fig. No. 23.—In Fig. No. 23 a condition is shown which may be regarded as a second stage of inflammatory progression in the evolution of a pus-pocket. It will be noted at once that the inflammatory infiltration is more extensive than that shown in Figures Nos. 21 and 22, and that some of the epithelium at the extremity of the gingival crevice has been lost. Superficial loss of tissue lying between the remaining epithelium and the tooth structure is taking place, the condition being one of ulceration.

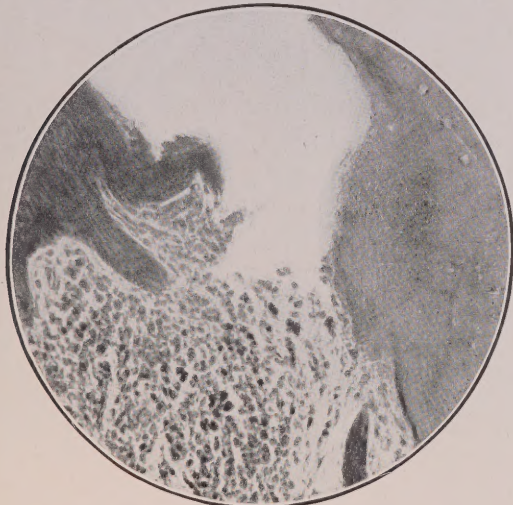


FIG. NO. 24.

Fig. No. 24.—This figure is a high magnification of the inflammatory process occurring in the tissue lying between the epithelium and the tooth, as shown in Fig. 23. It is clearly shown that some loss of tissue has taken place, and the remaining superficial tissue is in a state of ulceration.

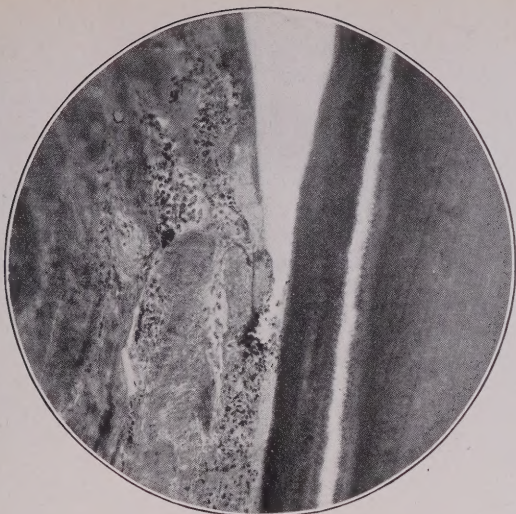


FIG NO. 25.

In Fig. No. 25, the third stage in the evolution of a pus-pocket is demonstrated. The ulcerative process has resulted in the partial denudation of cementum, and in the cemental gingiva a small pocket has been formed. Note, in this case, that extension of the ulcerative process is not proceeding along the cemental surface; and also the evidence of inflammatory reaction in advance of the pus-pocket.

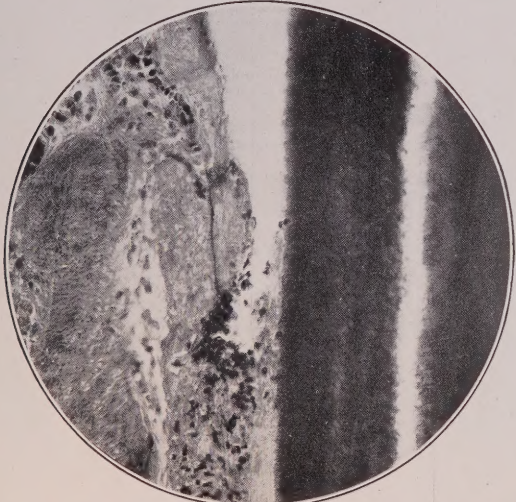


FIG. NO. 26.

Fig. No. 26 shows a high magnification of the pocket just described. Note that the pocket extends from the crevicular epithelium, which may be seen near the top of the slide, to the surface of the ulcer.

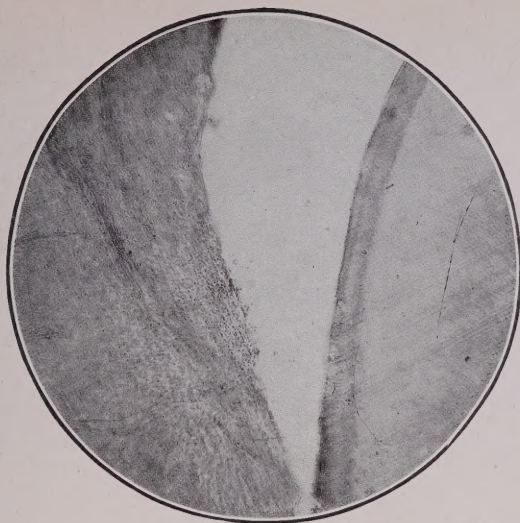


FIG. NO. 27.

In Fig No. 27 is an example of the fourth stage in the pathological evolution of a pus-pocket. Loss of tissue, denudation of cementum and pocket formation, have progressed into the pericementum. All the soft tissue facing the cemental surface is in a state of ulceration.

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The Rupert Hall Method for Entire Upper and Lower Dentures

Edited by W. E. Cummer, and
Revised by Dr. Hall



Bulletin No. Two

ISSUED BY
The Canadian Dental Research Foundation

The Rupert Hall Method for Entire Upper and Lower Dentures**

COMPILED FROM NOTES OF THE MEMBERS OF THE HAMILTON
CLINIC CLUB* H. A. SEMPLE, W. G. TRELFORD, AND
OTHERS. EDITED BY W. E. CUMMER, AND REVISED
BY DR. HALL HIMSELF.

SUMMARY.

Preliminary.

1. Scope of the system.
2. Definitions.
3. Forces which tend to displace and dislodge full upper and lower dentures.
4. Forces which retain full upper and lower dentures.
5. Adhesion and cohesion: partial vacuum and atmospheric pressure.
6. Capillary force.
7. The scheme of utilization of these forces in full denture design.
8. The tidal vacuum.

Examination of the Case.

9. Local examination of the edentulous mouth.
10. Classification of cases.
11. Class 1—cases of greater difficulty.
12. Class 2—cases of lesser difficulty.

Taking the Impression—(Cadillac)

13. Impression trays—their choice and adaptation.
14. The Hall Impression Tray Compound.
15. Preparation of Hall's Impression Tray Compound.
16. Application of material to upper tray.
17. Insertion and first impression—upper.
18. Object of manipulation of margin of impression.

*The undersigned would like to express his very great indebtedness to the Hamilton Clinic Club, through the kindness and hospitality of which a large part of this material has been available.—W. E. C.

**Bulletin No. 2 Canadian Dental Research Foundation.

19. Technic of massaging and muscle-trimming at this stage, which approximately forms the periphery of the impression.
20. Removal of first impression from Britannia-metal impression tray, final massage and muscle-trim.
21. Repair of minor breakages at this stage.
22. Trimming compound at beginning of "muscle-trim" at anterior frenum.
23. The final muscle-trim of the buccal and labial parts of impression.
24. Tests for finished muscle-trim impression.
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36. Boxing the impression.
37. Preparation for pouring the cast.
38. Stones, their use and hydration.
39. Mechanical vibrators for introducing stone into impression.
40. Removal of impression and "boxing" from cast.
41. Brief summary of steps, Hall "Cadillac" impression.
42. The Hall "Pierce Arrow" impression.
43. Indication for the "Pierce Arrow" impression.
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46. The pressure of application of peripheral valve seal for this impression.
47. Removal, holing, and trimming off excess.
48. Balance of the impression.
49. Brief summary of steps, Hall "Pierce Arrow" impression.
50. Hall "Ford" impression.
51. Securing the first impression and its preparation for the lining mix.
52. Completing the impression.
53. Brief summary of steps, Hall "Ford" impression.

54. Hall lower impression.
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61. Trimming and preparing for manipulation on periphery.
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63. Muscle trim for masseter muscle.
64. Muscle trim lingual anterior half of lower impression.
65. Muscle trim posterior half of lower impression.
66. Correction and relief at mylo-hyoid ridge.
67. Preparation of lining mix, insertion and removal.
68. Applying collodion, boxing, filling, and separating.
69. Summary of steps, full lower.
70. Avoiding exaggerated border pressure.
71. Choice of method, and conclusion.

N.B.—This article is intended to cover impression work only. It is hoped that in the near future the balance of the method will be compiled.

PRELIMINARY.



EDENTULOUS humanity has received from the dental profession through her sons many great contributions which pile up the sum total of knowledge and skill available for the relief of this particular distress; and none are more worthy of a high place by reason of simplicity, well within the range of the average dentist, and almost uniformly happy and frequently amazing results, than that system that Dr. Rupert E. Hall has built, it is true, upon the life work of others who preceded him, but endowed with such a proportion of the fruits of individual labor, observation and research,

well tempered with a plus amount of plain so-called "horse sense," as to well deserve the name of the Hall system.

1. SCOPE OF THE SYSTEM.

The entire process of full denture making as propounded by Dr. Hall bears the mark of his individuality, and includes: (a) impression making using in a special manner special materials original with

him,—the impression includes vault ridges, etc., also the peripheral tissues buccally and labially; (b) anatomical articulation, including an original articulator; (c) the development of “art which conceals art” in choice and arrangement of teeth and in the carving of wax and vulcanite; (d) the entire theory and practice of making rigid and accurate vulcanite dentures from these, also including a special flask with a screw piston packing device.

2. DEFINITIONS.

The peculiar needs of Dr. Hall's system indicate a more or less special nomenclature, including some new, also some old, terms. Quoting Dr. Hall in a reprint for the students of the Chicago College of Dental Surgeons, and by his courtesy for the students of the Royal College of Dental Surgeons:

The Term Jaw. Jaw may be defined as meaning all surface tissue of the jaw ridge, and in case of the upper the hard palate, upon or about which the base of an artificial denture is adapted and indirectly supported or retained excepting then, the attached flexible peripheral tissues. These may be more specifically described as all tissues, the fixed or rest positions of which are not modified by muscular action.

Flexible Peripheral Tissue. Flexible peripheral tissue may be defined as meaning all tissues attached to the jaw that are moved or are movable by the action of the muscles, including the soft palate.

Base. Base may be defined as meaning that part of a surface of an artificial denture that is adapted to and covers that jaw.

Periphery. Periphery may be defined as meaning that part of the border of an artificial denture adjacent to or continuous with the base that is adapted to and covers the flexible peripheral tissues.

Interposed Saliva. Interposed saliva may be defined as meaning the saliva interposed between the denture and the adapted tissue, held by capillary force.

Adaptation. Adaptation may be defined as meaning degrees of conformity and closeness of apposition of the outline and the surface of the base and periphery of an artificial denture with that of the jaw and flexible peripheral tissues to establish such a relationship as will bring their surfaces within the required distance or proximity to each other and make active the adhesive and cohesive of the interposed saliva between and through the complete surface of the jaw, flexible peripheral tissues, base and periphery of the denture.

Basal Seat. Basal seat may be defined as meaning the relation which the base of the denture bears to that of the indirectly supporting or retaining jaw in a state of adaptation. The jaw does not support or retain the base directly but indirectly through the medium of

interposed adhering saliva, the actual seat of the denture being formed and made up by and of the film of the interposing saliva upon or about which, through its adhesive and cohesive forces, the structure is supported or retained.

Peripheral Valve Seal. Peripheral valve seal may be defined as meaning a sufficiently light adaptation between the periphery of the denture and the flexible peripheral tissues to only affect valve action and prevent the ingress of air beneath the base of the denture in case of displacement, which breaks up capillary attraction and consequently adhesion. Too tight an adaptation interferes with circulation, resulting in shrinkage of tissue and loss of fit.

Retention. Retention may be defined as meaning resistance of the restoration to displacement and dislodgment.

Displacement. Displacement may be defined as meaning any change in relation of the base with that of its basal seat.

Dislodgment. Dislodgment may be defined as meaning breaking of the seal of the peripheral valve.

3. FORCES WHICH TEND TO DISPLACE AND DISLODGE FULL UPPER AND LOWER DENTURES.

These may be listed for the upper denture as follows:—

- (a) The articulation of the opposing teeth, including incision and mastication, in dentures not built on the principle of anatomical articulation or which interfere in side or protrusive movements, with unevenly distributed or dislodging pressure on dentures. In properly articulated dentures, incising and masticating movements, generally speaking, tend to seat the dentures more firmly.
- (b) The presence of unmasticated food, especially in dentures where no provision is made for unmasticated food. In Dr. Hall's system of anatomical articulation provision is made for the care of unmasticated food.
- (c) Contracting muscles, if these interfere with the borders of the denture, which are too long.
- (d) Teeth placed outside the ridge.
- (e) Gravity.
- (f) Any or all of above.

For the lower denture:—

- (a) The articulation of the opposing teeth, including incision and mastication.
- (b) The action of the tongue, especially if the lingual borders of the denture are too long.
- (c) The action of the contiguous muscles, if the labial and buccal borders are too long.

- (d) Teeth outside ridge as above.
- (e) Unmasticated food, as above.
- (f) Any or all of above.

4. FORCES WHICH RETAIN FULL UPPER AND FULL LOWER DENTURES IN POSITION.

These forces in the upper are adhesion and cohesion; partial vacuum and atmospheric pressure. Capillary force is also operative retaining the interposed film of saliva in place.

In the lower these same forces are operative in a lesser degree, assisted somewhat by gravity.

5. ADHESION AND COHESION; PARTIAL VACUUM AND ATMOSPHERIC PRESSURE.

These are commented upon by Dr. Hall as below:—

Adhesion means the force exerted by the attraction of unlike molecules for one another.

Cohesion means the force exerted by the attraction of like molecules for one another.

Vacuum means confined space devoid of matter.

Partial vacuum means confined space with degrees of emptiness.

Atmospheric pressure means the force exerted by the weight of the atmosphere which envelops the earth, the weight of which, at sea level, exerts a pressure of 14.7 lbs. pressure to the square inch.

The physical forces retaining an artificial denture in the absence of valve seal are adhesion and cohesion. The physical forces retaining an artificial denture with valve seal are adhesion, cohesion and atmospheric pressure, the force of the atmosphere being potential (inactive), which at the point of displacement becomes kinetic (active).

Adhesion in this particular is the aggregate molecular attraction exerted by the molecules of the interposing saliva for those of the substance of the structure of the base of the denture and those of the adapted tissues.

Cohesion is the aggregate molecular attraction of the molecules of the interposed saliva for each other in value as the surface and conformity of the base and hugs the adapted tissues and the amount of interposed saliva is minimized.

Atmospheric pressure, contrary to the opinion of many, is not a kinetic force acting conjointly with adhesion and cohesion in the position of the basal seat. The space between the denture and adapted tissue is completely filled with aerated saliva equalizing the pressure within the space with that of the atmosphere without the space. Were the maximum pressure of the air by complete removal of the interposed saliva and evacuation of the space thus formed, we

could then have the maximum pressure of the air 14.7 lbs. pressure to the square inch of base and peripheral surfaces covering the tissues retaining the denture as a kinetic force. But could the maximum pressure of the air be utilized through such source the human tissues will not tolerate permanently even a partial vacuum of an appreciable degree. We see this commonly demonstrated in the air chamber used to aid retention of upper dentures by this means. Hypertrophy of the tissues occurs, and the cavity fills. Thus do we conclusively show that atmospheric pressure cannot be utilized as a constant force to retain artificial dentures, owing to the fact that the interposed film of aerated equalized saliva between the denture and the adapted tissues cannot be dispensed with, and nature will not tolerate the negative pressure of vacuation about her tissues to make manifest such pressure by means of vacuum chambers. Therefore it must be considered that we have no degree of vacuation existing between the denture and the adapted tissues, consequently no possible aid from atmospheric pressure retaining the denture in the position of the basal seat, but it is supported or retained in proximity with the adapted tissues by the attraction of the molecules of the interposed liquid for those of the denture.

Since we know the relation or state defined as adaptation not to exist when an artificial denture first is introduced into the mouth, and until adaptation evolves by wearing the denture, permitting the tissues, as they do, to fill in and shape themselves to conformity and apposition with the surface of the base, we know also that during this introductory period, so to speak, while the tissues are adjusting themselves establishing adaptation, partially evacuated space exists between the denture and that atmospheric pressure is an aiding force retaining a denture conjointly with cohesion and adhesion. Also does it solve in part the perplexing puzzle of why many dentures lose their fit-so-called? Nature responds to the negative pressure of evacuation, the tissues fill in and obliterate the spaces and the force of the atmosphere becomes nil, and the denture is retained by adhesion and cohesion only, partly explains this, but more often faulty technic on the part of the dentist, by too tight a peripheral valve seal, with interference to circulation and "strangulation," loss of bulk tissue, and loosening of denture.

6. CAPILLARY FORCE.

Capillary force is that force that retains a thin film of liquid between two closely approximated surfaces. In the case of a full artificial denture, should the capillary film of interposed saliva become broken and replaced with air, adhesion is immediately destroyed. Capillary force is protected in denture design by special care to secure an accurate contact around that entire periphery of

the denture called peripheral valve seal, the word valve being used originally by Dr. Green to indicate *just sufficient* pressure to prevent leakage of air into the capillary film of saliva during a dislodging. The most favourable form of periphery is secured by an impression which registers slight pressure of the tissues overlapping the periphery while these tissues are at rest, and not interfering with muscle action, save in the distal part of the upper in which the tissues do not fold over the edge of the denture, in which case the most favorable form is a tapering edge rounded off sufficiently not to cut the soft tissues, also set at a position of slight pressure.

A most excellent chapter upon the question of atmospheric pressure as it relates to denture retention is that contained in Wilson's Dental Prosthetics, by George H. Wilson, and is earnestly commended for careful reading and study.

Since the retaining force offered for resistance to displacement by adhesion and cohesion alone is low in comparison with that required to resist the displacing forces of efficient incision and mastication, displacement of the denture easily and readily occurs.

How then may aid by utilization of the force of atmospheric pressure be accomplished for retention of an artificial denture for the sufficient incision and mastication of food?

Aid by means of the force of the atmosphere may be indirectly accomplished by the formation of an emergency partial vacuum arising momentarily and simultaneously with the displacement of the denture by the force of incision and mastication or by any other forces causing the displacement of the structure, hence:—

7. THE SCHEME OF THE UTILIZATION OF THESE RETAINING FORCES AND THE AVOIDING OF DISLODGING AND DISPLACING FORCES IN DENTURE DESIGNS.

Quoting Dr. Hall further:—The requirements of denture design for the accomplishment of the emergency partial vacuum are that the base of the denture should cover and be adapted to the entire surface of the jaw, and have added to it a periphery with the border surface continuous with that of the base of the denture, and that the surface of such border be extended upon and lightly adapted to the flexible peripheral tissues, protecting capillary force, so that there is created a valve-like action between the flexible peripheral tissues and the surface of the periphery, to preclude therewith the ingress of air under the base of the denture and resist or prevent dislodgment of the same, through the indirectly applied resisting force of the atmosphere should displacement occur.

Preventing the ingress of air between the surface of the base of the denture and the tissues of the jaw at the time of displacement of the restoration, sealing the space occurring between the base and the

jaw without admitting the air, forms simultaneously with displacement a partial vacuum in which capillary force is partially destroyed.

8. THE "TIDAL" VACUUM.

The tidal or momentary partial vacuum created between the base of the denture and the adapted tissues of the jaw is therefore manifested only when the resistive forces of the cohesion of the molecules of the interposed saliva are overcome and partial displacement of the denture occurs. Since the resultant atmospheric pressure is the direct force resisting dislodgment of the denture when forces displace the structure, forming a retentive partial vacuum, it is obvious that any force that creates and increases the space, degrees of vacuity and resultant atmospheric pressure, increases simultaneously resistance of the denture to dislodgment. The degree of vacuity of space is in direct ratio to the volume of the vacuum, owing to the fact that the sealed periphery precludes the ingress of air and the increasing space between the base and the jaw still accommodates the same quantity of air. Boyle's law governing the relationship between the pressure and volume of gases under a constant temperature covers this point, and is as follows:—"Pressure of a given mass of gas varies inversely as the volume of the space within which it is confined." That is, if the volume of a space existing under the denture consists of 1 c.c. at a pressure of one atmosphere, when increased to two c.c. of volume the pressure according to this law would be one half of an atmosphere. Therefore:—extent of adapted surface tissues, then, determines the relative of the respective forces exerted by adhesion and cohesion.

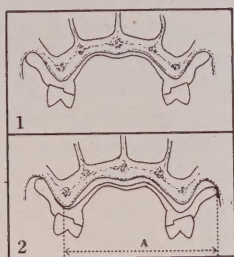


Fig. 1.—Tidal or emergency vacuum. In No. 1 the denture is shown in cross-section as in place, held by adhesion alone and the pressure not active. In No. 2 the same denture is shown in a displaced position. If the peripheral valve seal holds say between distance, so there is a pressure per square inch between these points, depending on the degree of rarification in empty space beneath denture.

Peripheral construction and adaptation for a seal and valve-like action with the flexible peripheral tissues, sealing space occurring

*The retention between two surfaces with a capillary film of liquid between is not lessened in any degree in a vacuum.

between the base and jaw created by displacement of the denture, preventing the ingress of air, forming a relatively increasing partial vacuum indirectly applying the force of the atmosphere thereby, aids in preventing or oppose dislodgment of the artificial denture should displacement occur.

Credit for the construction and establishing such design and relations between the base, periphery, jaw and flexible peripheral tissues, should, in so far as we are informed, be given Dr. W. V. B. Ames, of Chicago, for he it was who first conceived of their importance in 1885 (Independent Practitioner, July), demonstrated their principles; others notable in early appreciation and use of their principles were the Greene Bros. of Missouri.

EXAMINATION OF THE CASE.

9. LOCAL EXAMINATION OF THE EDENTULOUS MOUTH.

In the examination of the mouth for any definite object a definite sequence is of value. Here below are items as listed for a physical examination of the edentulous mouth as taken from an admirable work, a classification by Dr. M. W. House, of Indianapolis. (Pre-supposing the general examination has been already done and all oral conditions made healthy.)

(a) *Tone and development of the muscles of mastication and expression.*

1. A case in which degenerative changes have not occurred.
2. A case where approximately normal functions have been preserved by the wearing of artificial dentures.
3. A case in which a subnormal condition has resulted from the absence of natural or artificial dentures, or from the wearing of inefficient artificial dentures.

(This assists in a prognosis as to masticating efficiency.)

(b) *Bony Structure.*

Physical size.

1. Large upper or lower, affording the greatest possible advantages for stabilizing the dentures.
2. Medium size, affording less advantage for stabilizing the dentures.
3. Small size, presenting much difficulty in stabilizing the dentures and affording much less efficient service.

(Note)—Any mouth may present one class upper and another class lower. Note also anterior and posterior foramina.

Arch form.

1. Square type.

2. Tapering type.

3. Ovoid type.

(Note)—Any mouth may have one class upper and another class lower arch form.

Physical form of alveolar ridges.

1. With contours favorable to the aesthetic and efficient adaptation of dentures.

2. With contours presenting minor difficulties of the aesthetic and efficient adaptation of dentures.

3. With contours which demand surgical interference to permit of aesthetic and efficient adaptation of dentures.

(The above assist in a prognosis as to masticating efficiency and appearance.)

Soft tissues.

1. Normal uniform density of investing membrane of 1 mm. or 2 mm. thickness over the area to be covered by dentures.

2a Hypertrophied tissue conditions resulting in thickened investing membrane which may be efficiently controlled by proper denture form.

2b Entire investing membrane very thin and easily irritated; may be controlled by proper denture form.

3. Hypertrophied tissue conditions resulting in excessive thickening of investing membrane which necessitates surgical interference.

(The above is concerned with the ability of the tissues to carry strain, and the necessity or no for compensation hard or soft areas.)

(c) Border tissue attachments.

Upper (Ocular or digital examination).

1. High.

2. Medium.

3. Low.

Lower.

1. Low.

2. Medium.

3. High.

(d) Muscular attachments.

Upper.

1. High.

2. Medium.

3. Low.

Lower.

1. Low.

2. Medium.
3. High.

The border tissue and muscular attachments and their characteristics have a bearing on the amount and direction of the massage, and the amount of pressure in peripheral valve seal. The examination is best done with finger and with mouth down.

(e) *Throat form.*

1. Large and normal in form with the immovable tissue of the soft palate extending posteriorly from the hard area from 5 mm. to 12 mm., at which point the curtain of the soft palate becomes movable with a decidedly large range of movement. This is usually found in a large type of mouth.
2. Medium and normal in form, having an immovable tissue approximately 3 to 5 mm. posterior to the hard area.
3. Small and little or no immovable tissue posterior to the hard area, the curtain of movable soft palate turning down abruptly within 2 mm. of the junction of hard and soft areas,—such mouths are usually without tuberosities and present difficult problem. In each case note two tubercles at separation of hard and soft palate, also noted by having patient say "ah." (This has to do with the pressure and extent of post-damming.)

(f) *Saliva*, concerning quality of adhesion, tidal vacuum, and also peripheral valve seal.

1. Normal in quantity and quality, offering a favorable condition.
2. Abundance of semi-viscid ropy saliva.
3. Excessive amount of extremely viscid saliva.

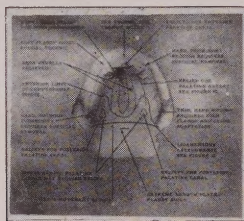


Fig. 2.—The Edentulous upper jaw and its parts. Clapp and Tench.

10. CLASSIFICATION OF CASES.

A simple working classification is offered by Dr. Hall, in which cases presenting may be divided into two classes, with three different methods of taking impressions used.

Class No. 1, as per item below, presents more difficulties than

Class No. 2. In Class No. 1, cases of unusual difficulty, Dr. Hall's most elaborate and probably most effective impression technic is used, which he affectionately, after a well-known automobile, dubs "Pierce Arrow" impression technic, consuming two separate sittings of probably a half or three quarters of an hour each, with a special vulcanite tray. For Class No. 2 cases, of moderate difficulty, the impression technic so-called "Cadillac," consuming probably half to three quarters of an hour, is used; and for Class No. 1 cases, those of least difficulty, a simple impression in two operations, consuming approximately fifteen minutes, named after the proletarian "Ford."

11. CLASS 1—CASES OF GREATER DIFFICULTY.

Cases where the ridge is not prominent and the hard palate is flat, muscle attachments are low, thus making retention of denture difficult, are included. In making restorations of this kind it is necessary to make retention by making denture somewhat high around the peripheral border, and by slightly "post-damming" the soft palate. Denture will fit tightly at first, but may become loose as the peripheral border pushes the tissues. Doctor Hall, indeed, occasionally uses this method in cases of unusual difficulty in which the soft tissue attachments approach the crest of the ridge, for the express purpose of pushing them permanently back, virtually developing a ridge. In such cases the impression is made, the plate worn till it loosens, and a new impression is made using the same plate as an impression tray, but with somewhat higher peripheral border "traced on," subsequently converted to vulcanite (rebased). This process is repeated until sufficient ridge is developed, the final plate carrying the usual peripheral valve seal.

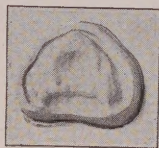


Fig. 3.—Model of case in which ridge has been practically developed by a series of "Pierce-Arrow" impressions, described later in these notes; treatment extending over thirteen months, with five complete dentures and three rebasings; an extreme case.

See Figure 3.—As stated above, the "Pierce Arrow," and, for Class I cases of more moderate difficulty, "Cadillac" technics are used for this type of case, depending upon difficulties.

12. CLASS 2 OF LESSER DIFFICULTY.

Cases which may be called average cases, where a good ridge is available with a high palate and where "post-damming" is not

necessary, are included in this class. These cases will be in the majority in general practice, and the method used will be much quicker, consequently less expensive for patient,—the denture fitting well from the start and in most cases remaining so without further attention, and requiring the so-called "Ford" impression technic.

TAKING THE IMPRESSION (CADILLAC).*

13. IMPRESSION TRAYS—CHOICE AND ADAPTATION.

An assortment of eight Britannia-metal trays or their equivalent is considered by Dr. Hall as adequate. They are as follows:

S. S. White, Upper Nos. 1, 2, 3.

S. S. White, Lower Nos. 1, 2, 3, 18 and 19.

Nos. 18 and 19 will be found to have a shaped lingual flange for lower mouths at the oblique ridge lingually.

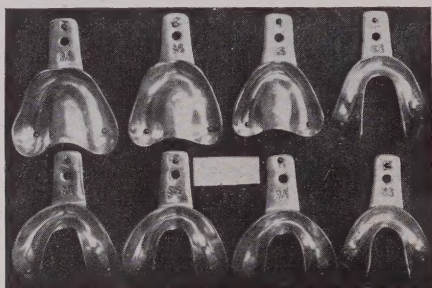


Fig. 4.—Trays Used for all Technic. Upper 1-2-3, Lower 1-2-3-18-19. These common forms, used with the Hall impression compound material, cover a wide range of cases.

But with regard for adaptation of these trays, the general principle should be followed, of allowing at least a quarter of an inch for the impression material itself; too close an adaptation of the tray is not necessary, as the excess is removed after the first impression, and the impression itself is thinned down as required.

14. THE HALL IMPRESSION TRAY COMPOUND.

One of the primary reasons in the mind of Dr. Hall, in devising this material, is the necessity for a material sufficiently while cool that, after having been softened and pressed into place against the jaw in an impression tray, both the tray and the impression removed, the tray itself then separated from the compound, that the remainder consists of a special tray of hard material having the

*Sections 13 to 40 describe the technic of the impression of middle difficulty, or rather for cases of middle difficulty. (See Section 10). Section 40 will describe the impression of greatest difficulty (Pierce Arrow) and the impression of least difficulty (Ford) using the above as a basis.

accuracy of a special tray rapidly secured to which low heat ordinary modelling compound may be "traced on" or removed if necessary, and the whole, after suitable manipulation of muscle trimming, post damming, and similar, is filled with a very thin mix of plaster, and actually used as special impression tray.

15. PREPARATION OF HALL'S IMPRESSION TRAY COMPOUND.

Either of the trays mentioned in Section 12 are prepared by ordinary methods of sterilization, and with a polished surface to facilitate ready separation of material. Sufficient of the material (about 2 cakes for an upper, and $1\frac{1}{2}$ cakes for a lower) is dropped into an enamel pan of water heated to a temperature of 180° F., with blotting paper or similar in bottom of pan to prevent sticking. (This temperature checked, if desired, by a small chemical, confectioner's, or better still a Supplee thermometer fastened to the side of the enamel dish and reading at least 212° F.) Before the material is dropped into the water at 180° F., the pan should be removed from the heater, or vice-versa, thus preventing the sticking of the material to the bottom of the pan, also its deterioration. The cold material dropped into water at 180° F. absorbs sufficient heat in a few minutes to become raised in temperature to 160° F. (the water temperature also becoming reduced to 160° F.), which is a satisfactory working temperature for this material.

16. APPLICATION OF MATERIAL TO IMPRESSION UPPER TRAY.

This may be done by raising the now plastic material from the bottom of the pan with a glass paddle (Supplee), metal paddle or similar, keeping fingers wet to prevent sticking. After rapidly rolling the material into the shape of a ball, the creases which occur are worked away from the surface by a process of revolving the ball of compound upon the two index fingers and sliding the thumbs both downward upon the ball of soft compound, pushing all the seams below, towards the index fingers, also completely softening any partly softened particles in the mass, at which time it is quickly placed on the tray with the thumb-smoothed part upwards, and with a sidewise movement of the thumbs quickly worked to place of a shape perhaps a little fuller in the centre, and heaped or pinched up a little at the sides.

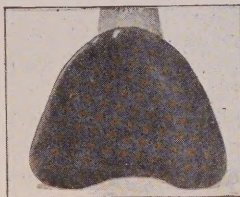


Fig. 4A.—Britannia-metal tray filled with Hall Impression-Tray Compound, ready for insertion in the mouth.—(Courtesy S. S. White Co.)

This having been accomplished, the material is then quickly passed over the flame, giving it a gloss, then quickly immersed in the water, to prevent burning of patient's mouth, now approximately at 140° F., at which time it is ready for insertion.



Fig. 5.—Applying Compound to Tray.

Step A.—Rolling material between thumb and first finger, rolling seams downward.

Step B.—Applying material to tray with seams against tray.

Step C.—Shaping material by pressing or wiping it outward against the flanges.

17. INSERTION AND FIRST IMPRESSION, UPPER.

Having completed the mounting of the material on the tray, and the patient having been prepared with chin napkin, rinsing water, etc., in a fairly upright position in the chair, with the head on a level with the operator's elbow, the operator quickly takes his position, partly behind and partly to the right side of the patient, so that by stooping slightly his head will be directly over that of the patient. The right heel of the impression tray is insinuated between the patient's lips in the usual way, drawing the cheeks to the right, and allowing the left heel of the tray to slip into the mouth. Should the mouth be small, a mouth mirror may be necessary to assist the left heel of the tray into position. (See American Text Book, Prosthetic Dentistry, page 332.) Having inserted tray, the operator's head being kept directly above and sagittally in line with that of the patient (this is of great assistance in "centring" the tray and impression), the tray is then pressed quickly and gently upward until a shallow print of the crest of the alveolar ridge is secured. This is quickly removed, left heel first, in the usual way, and the centring checked up. If not correctly in the centre, the operation is repeated until the impression is correctly in centre, using the position of the handle of the tray directly under the patient's nose as a guide. The tray is then pressed up with an intermittent movement until it has reached a position in which any part of the tray is not closer than 3-16 of an inch from the tissues, with this distance as minimum thinness of impression; with massage movements, hereinafter described, against the cheek, while the patient performs the act of protruding the tongue, for a definite object of carrying the distal excess in under the tray. The impression should extend about

an eighth of an inch back of the junction of the hard and soft palate. Note the tubercles at the back of impression indicating this, also movement of soft palate on patient pronouncing "ah."

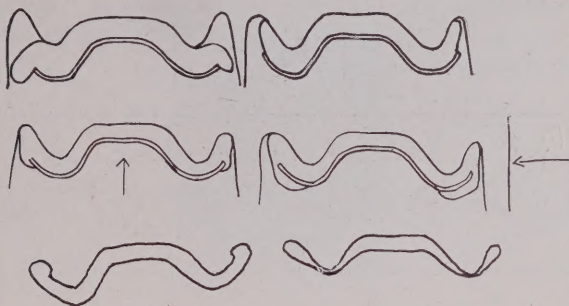


Fig. 6.—First Impression, Centering and Removal.

- (a) After removal, to check for centering.
- (b) In position before massage.
- (c) Massage partly begun.
- (d) Massage complete with excess pushed under tray.
- (e) Impression separated from tray, subsequently trimmed, and used as a special tray.
- (f) Impression tray pushed too far up:—result material too thin; must either be preferably discarded or reinforced.

18. OBJECT OF MANIPULATION OF MARGIN OF IMPRESSION.

An impression of the upper mouth which approaches the ideal is one which, while in *light* contact against the upper mouth, is in closest possible adaptation over the entire upper mouth, but at the extreme periphery and for a distance of approximately 1-8 of an inch inward, and also approximately 1-4 of an inch inward across the distal part of the denture between the maxillary tuberosities exerts slightly more pressure against the peripheral tissue, and also extends

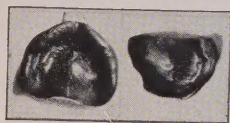


Fig. 7.—Impressions With and Without Massage and muscle-trimming. Note difference in detail which is in proportion to the uniform bearing upon the varying contours at the periphery.—(Courtesy Hamilton Clinic Club.)

slightly against these tissues, not, however, interfering with the muscles which act in this peripheral flexible tissue nor blood supply. See 70. See Section 2.

This has been defined as peripheral valve seal (see Section 2), and is useful in protecting the capillary fil of saliva against ingress of air on tidal vacuum or retention during partial displace-

ment. The flexible peripheral tissues, including the soft palate, are set in motion during the various movements of the lips, cheeks, etc., as smiling, guarding the food during mastication, speech, etc., and it is considered by Dr. Hall that the movements of "sucking" and "swallowing" embrace all of these sufficiently well for the purpose of the impression.

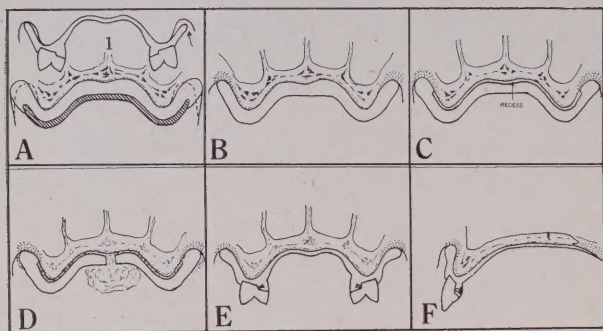


Fig. 8.—Peripheral Valve Seal, secured by manipulation in so-called "Cadillac" impression, for No. 2 Cases.

- (a) First stage with cheeks distended above a denture made from such an impression, no peripheral valve seal.
- (b) Second stage, with slight additional pressure at crest of periphery, only after massage and muscle-trim.
- (c) Third stage, after Kerr's Compound is placed on and pressed against the process at periphery.
- (d) Fourth stage, thin mix of plaster carried to place. Note hole for excess, also additional areas of pressure.
- (e) Finished denture made from above impression. Note areas of slightly additional pressure and contact only.
- (f) Antero-posterior view of same denture shown in (e). Note areas of additional pressure, especially 1-4 inch additional pressure at soft palate. (This is called "post-dam.")

Hence the action of massaging the cheeks lightly, and asking the patient to swallow and suck, approximately forms the entire margin of the impression to the shape of the peripheral valve tissue. At this stage, should the acts of sucking and swallowing be impossible for the patient to make, it may be omitted, to be resumed in the final trim should the patient be able to make them. In the upper this consists of a sharp cut in the anterior, varying in depth to accommodate the central frenum, high over the lateral and cuspids, with perhaps depression caused by fibres of the obicularis oris muscles, higher over the cuspids, often with a sharp depression for a buccal freedom immediately posterior, and varying and ascending contours caused by fibres of buccinator and masseter muscles until the maxillary tuberosity is reached; occasionally at this point the internal pterygoid muscle will impinge and press the soft impression material sharply away. Between the tuberosities the

form of the impression is shaped by the act of swallowing, the posterior tongue being in elevation and evenly pressing the material against the first one-eighth of an inch of the soft palate.

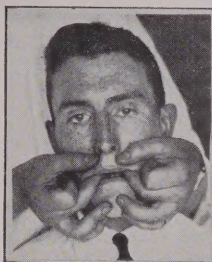


Fig. 9.—Position in Massaging Border of Impression. The pressure and direction of motion of the thumbs is important, and is indicated in Fig. 10.

19. TECHNIC OF MASSAGING AND MUSCLE-TRIMMING PERIPHERY AT THIS STAGE, WHICH OPERATION APPROXIMATELY FORMS THE PERIPHERY OF THE IMPRESSION.

Some little skill and experience is required to judge the exact amount of pressure and its directions to secure the result indicated in Figure 9, with a periphery shaped to accommodate muscle action which occurs in sections of the periphery, and the rest position of the flexible soft tissues, which occurs in the balance of the periphery, and also to obtain the slight pressure necessary in Figure 5. While at this stage the results expected are only approximate, yet it is advisable at this stage to approach the finished results as closely as possible.

As soon as the impression has been centred and pressed to place, as described in the previous section, and has been carried upward to place, the dentist by now in a position immediately behind and above the patient, both middle fingers are slipped to the centre of gravity of the impression under the tray, after, and if possible while, the patient makes suck and swallow movements, the thumbs are rapidly applied to the patient's cheeks a little above the periphery of the impression, which may be distinctly felt underneath.

An effort has been made in Figure 10 to indicate something of the results to the periphery of the softened (and now cooling and hardening) compound during operation, and an effort has also been made in the same figure to indicate the sequence of events to the compound in contact with flexible peripheral tissues themselves.

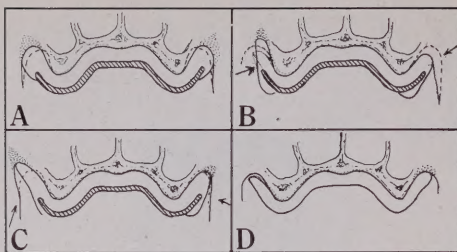


Fig. 10.—The Proper Application of Pressure in Thumb Massage of Upper Impression.

- (a) Before massage, peripheral flexible tissue, dotted line represents rest position of peripheral tissue. Note large distention of flexible peripheral tissue by excess of material at side of tray.
- (b) Pressure applied in a horizontal direction:—unless the pressure is extremely light the danger lies in pressing the material too far up, the rigid tray assisting in this, and with too much pressure upward in the finished plate, with irritation, and immediate loosening of plate where filed to relieve irritation. Dotted line indicates the rest position.
- (c) Pressure applied in too vertical an angle, with the result that the material is drawn down out of contact with the peripheral tissue. Dotted line indicates the rest position of the peripheral tissue.
- (d) Pressure and angle of pressure corrects, with the result that the periphery exerts a peripheral "valve seal." It is almost impossible to add further by way of explanation, except that the operator must "feel" the motion of the plastic compound through the thumbs, and through this feeling in mental vision of the position and the amount of pressure that it exerts upon the peripheral tissue.

An effort has been made in the same to indicate the sequence of events to the compound in contact with the flexible peripheral tissues themselves. In as few words as possible, the aim of the dentist is to cause such movements by massage and muscle-movement of the patient as to carry the impression material, at this stage, to a valve fit by slight extensions into the contours, at rest, and also as effected in sections by muscle action, and by actually mentally seeing and directing through the thumbs and fingers which cause the movement, the material to this position. It must also be remembered that, at this stage, the forming of these margins is only approximate, and is further corrected, as described below, by a repetition of these movements on the thinned and softened margins, with the tray removed.

20. REMOVAL OF FIRST IMPRESSION FROM BRITANNIA-METAL IMPRESSION TRAY, FINAL MASSAGE AND MUSCLE-TRIM.

The operation of removing the first impression from the tray is readily done by first trimming off the overhanging material, both buccally and distally with a *sharp* penknife, then by a smart tap with the back of the penknife on that part of the tray at which the handle joins the body, the tray is quickly separated without fracture from the first impression, which now becomes the special tray.

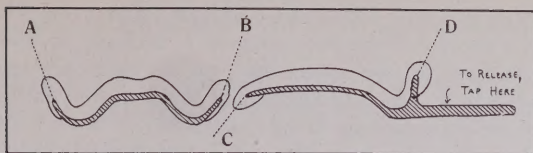


Fig. 11.—Trimming off overhang and releasing tray from the first impression, which impression now becomes the special tray, and which at a later stage is corrected with thin plaster. A-B-C-D line of division of overhang from body of impression, which is cut away, after which the impression may be separated from the tray by tapping the tray as indicated.

21. REPAIR OF MINOR BREAKAGES AT THIS STAGE.

Should, by any chance, a small fracture occur in separating the impression from the tray, a quick repair may be readily made by so-called “tracing-on,” by which a fragment or a previously prepared stick of material is held in the flame until the molten portion is ready to drip off from the balance, quickly applied to the buccal or lingual side of the fracture by the right hand, the left hand holding the parts in a position similar to the making of a small repair. Repetition of this will also sufficiently reinforce the material where thin, and if necessary pieces of sheet metal, heated to about 160° F., may be dropped in this, thoroughly reinforcing the part. Metallic pieces must not be placed closer than one-half an inch from the periphery, thus avoiding an interference with future muscle-trimming.

22. TRIMMING COMPOUND AT THE BEGINNING OF “MUSCLE TRIM” AT ANTERIOR FRENUM.

Following the removal of the first impression from the tray, the

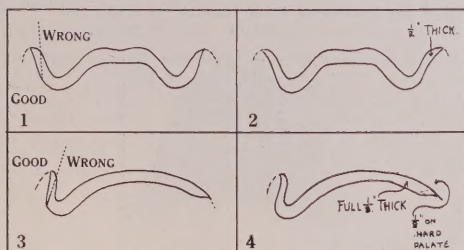


Fig. 12.—Trimming the Impression Immediately Prior to the Operation of “Muscle Trimming” (In Section 20).

- (1) First impression incorrectly trimmed, should be cut to crest of impression only.
- (2) Impression thinned down to one-eighth of an inch for half an inch, care must be taken not to cut centrally past the crest of the flange.
- (3) Side view of impression, after leaving metal tray, with wrong trim as in 1.
- (4) Trim for post damming one-eighth of an inch behind junction of hard and soft palate. This may be seen by asking the patient to open the mouth and say “ah” or by the so-called “Fovea Palatina” small depressions occurring slightly ahead of this.

first operation is to trim, with a sharp penknife, and a sharp Kingsley scraper, the margin of the impression to a thickness of about one-eighth of an inch, for the reason that, for the subsequent operation of muscle-trimming, which is the shaping of the heated and softened margins of the impression by muscle action produced by a suck and swallow (post-damming being the shaping of the distal part of the impression between the tuberosities, and muscle-trimming the shaping of the balance of the impression margins), the edge must be thin, otherwise the more or less delicate muscle action would not leave an imprint on the material.

Particular care should be taken not to remove any material past the crest of the flange of the impression, as the crest of the flange marks the semi-muscle-trimmed contour, subject to further shaping, as hereinafter described.

23. THE FINAL MUSCLE TRIM OF THE BUCCAL AND LABIAL PARTS OF THE IMPRESSION.

As may be noted in Section 17, the ultimate object of the manipulation of the impression is to place the periphery of the impression in valve contact with sufficient relief for muscle action.

At this stage these manipulations of warming the margin over a small flame and re-applying with gentle massage are repeated with probably less muscular effort on the part of the patient, and less massage pressure on the part of the dentists, on account of the thinner margin of the partly corrected impression. Should massage and muscle movement fail to turn back the softened edge, a deficiency of material must be assumed and more "traced on."

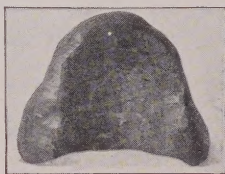


Fig. 13.—Thinning the lingual side of impression with a sharp knife and a sharp Kingsley scraper. The lingual bulk of the impression may be considerably reduced, adding much to the ease and facility with which it may be handled in the mouth during the subsequent operations.—(Courtesy S. S. White Company).

24. TESTS FOR FINISHED MUSCLE TRIM OPERATION.

It must again be pointed out that, at this stage, correction of the position of the now muscle-trimmed margin is largely a matter of judgment on the part of the operator, who, having in mind the

characteristics of a proper valve seal, as indicated in Figure , may raise the lip and observe whether or not the desired result is secured.

There are, however, other simple tests which may be used at this stage to test the corrections of the margin which may be as follows:

Possible errors at this stage:

- (a) Too close to the alveolar process.
- (b) Too far away from the alveolar process.
- (c) Too high up against the flexible peripheral tissues.
- (d) Too low or out of contact with the flexible peripheral tissues, especially at frenum or over maxillary tuberosities.
- (e) Any possible combination of the foregoing, treated below in the same order.

Their corrections:

- (a) Should the material be too close, the patient will feel discomfort, and a blanching may be noted on examination. To correct: reheat at this part, reinsert and re-massage.
- (b) Should the material stand out too far from the alveolar process, this will be distinctly noted by pressing slightly the margin with the index finger, as the margin will be felt to stand away from the process as a shelf. To remedy: re-heat and re-massage.
- (c) Should the material be too high up, a tendency may be noted to throw the impression down, or the cheeks or alae of the nose may seem to be slightly dislodged, and with finger on the cheek the subjacent tissue may seem crowded. This is the malposition most difficult of detection, and which requires the most experience and judgment, and it is quite possible for an experienced operator to be in error in this particular. Correction: re-heat and re-massage.
- (d) Margin too low. This may be detected by bubbles of saliva oozing out on the insertion of impression, and lack of adhesion also of impression. Remedy: trace on material, reinsert and re-massage until correct.

25. THE OPERATION OF POST-DAMMING.

Post-damming is practically "muscle-trimming," only in location, the distal part of the upper plate between the tuberosities, and is the operation of securing peripheral valve seal without interference with moving tissues between these two points. The increase of adhesion to an impression is often most startling, after post-damming has been done to an already correctly muscle-trimmed (buccally and labially) impression.

Should the impression not reach one-eighth of an inch past the hard palate and lap upon the soft palate, this distance, the black compound should be traced on until the entire impression not only reaches this length, but also amply covers the tuberosities.

This having been accomplished, the actual operation of post-damming begins, as indicated in Figure 14, which is the securing of a valve fit, or slightly additional pressure from one-eighth to a quarter of an inch on the soft palate. A stick of Kerr's Compound (red stick) is taken, and the material is "traced on" the palatal surface of the impression, the whole distal part passed once or twice through the flame to secure uniform plasticity of the Kerr's Compound, with minimum softening of the Hall's Compound below.

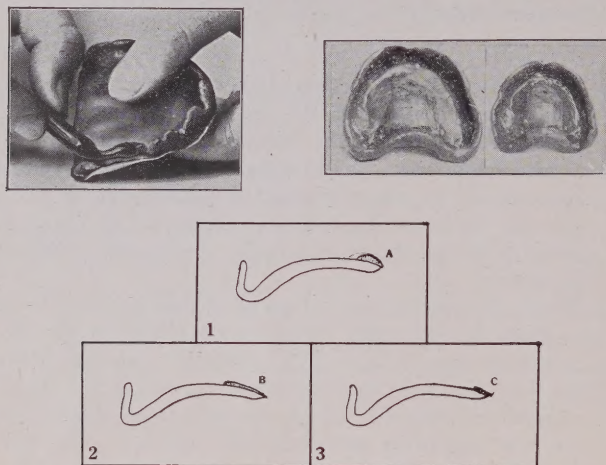


Fig. 14.—Stages of post-damming Hall impression.

- (1) Shows first step, soft Kerr's Compound stick is heated and traced upon the impression tray of Hall's black compound, which remains rigid, having a softening point of 20° above that of Kerr's Compound sticks.
- (2) After insertion in the mouth, with the patient swallowing, while the Kerr's Compound is still soft, the elevation of the tongue in the act of swallowing exerts uniform upward pressure upon the distal part of the impression, compressing the softened compound against the anterior soft palate, and if correctly done completes the valve fit against the peripheral tissue, with usually a marked adhesion, but with the valve contact too wide. The drawing of the wet finger gently across this a few times will prevent the material "sagging" out of contact.
- (3) With a Kingsley scraper the "post-dam" is trimmed from anterior towards posterior until the contact is from one-eighth to one-quarter of an inch on the soft palate,—the poorer the anterior ridge, the greater the contact necessary. This should not come in contact with the hard palate, as irritation and overload at this point would result.—(Courtesy Hamilton Clinic Club).

The distal half of the impression is then quickly dipped in warm water (approximately 160°), to prevent burning of the compound

just removed from the open flame, and quickly seated in the mouth of the patient, with instructions to swallow twice at least. If for any reason (for example, a softened anterior ridge) a little extra pressure on the soft palate is desired, the forefinger may be "wiped" across, giving the light pressure desired. This should, however, not often be done, for the reason of possible excess peripheral pressure with strangulation and consequent shrinkage of the entire jaw.

The patient should then be asked to make dislodging movements, and if a satisfactory adhesion is found the next step is proceeded with. If not, a lack of contact may be looked for and usually found by inserting the wet impression and slightly moving up and down, exhibiting air bubbles at the part which is at fault. Tracing on of material and heating at least a quarter of an inch on either side, with suitable massage, as already described, will in all probability correct this.

26. RELIEVING THE CENTRE OF THE IMPRESSION.

Here follows the operation of scraping out the entire centre or vault portion of the impression with a sharp Kingsley scraper, beginning from about one-eighth to one-quarter of an inch from the extreme periphery and relieving the entire centre to approximately the thickness of probably 18 gauge Brown and Sharpe, as indicated in Figure 15.

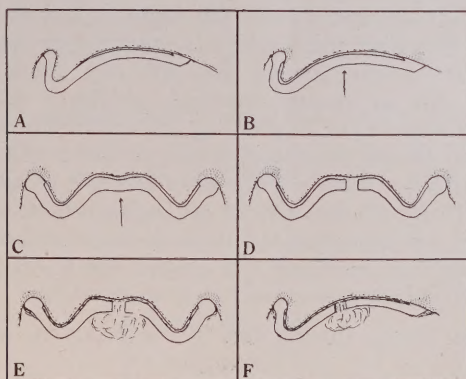


Fig. 15.—Relieving and Holding the Impression.

- (1) First impression immediately after completed post-damming.
- (2) Impression after entirely relieved, air space over entire centre. A denture made from such an impression would be retained by atmospheric pressure alone, and would not be practical because the extreme pressure would partly cut off the articulation as well as badly cut the tissues, and the central soft tissues would ultimately fill the partial vacuum.
- (3) Lateral section of No. 2.

- (4) The final operation to the first impression of "holing" or drilling a small hole, 1-8 of an inch or a trifle less, to allow the excess plaster in the final step to escape. Immediately after "holing" the impression loses its atmospheric pressure and is held by a small adhesion over a narrow periphery only, therefore loses practically all of its retention, which comes back considerably augmented after the final step of lining with plaster.
- (5) Addition of the final plaster,—this should secure the ideal conditions desired, i.e. accurate contact over the entire jaw, producing adhesion, and peripheral valve seal at periphery, which provides for the tidal vacuum.
- (6) Longitudinal section as in No. 5, at the line of contact of the muscle-trimmed and post-dammed periphery, the plaster must be so thin that the finished impression on removal should show this to (See Figure 21).

27. PHYSICAL BASIS OF THE STRONG RETENTION SECURED AT THIS SAGE, AND THE REASON FOR THE IMPOSSIBILITY OF SUCH IN A FINISHED IMPRESSION.

The next step of "holing" the impression as indicated in Fig. 12, an impression with central relief and contact at periphery only would be strongly retained should the patient make a strong exhaustive movement or "suck" in the mouth, in the mouth fifteen inches of a vacuum, corresponding roughly to seven and one-half pound pressure to the square inch, may be secured by many, and estimating the area as approximately four square inches in such a combination, and presupposing accurate adaptation at the periphery, an upward air pressure against the partial vacuum would total thirty pounds in the denture. This would not be practical, because this strong pressure would be concentrated on the soft periphery and would not only cut off the circulation, but would cause injury from such an overload, and as the ideal denture rests with even pressure upon the entire jaw with, as already described, peripheral valve seal, or slightly increased pressure at periphery, provisions must be made for the final step for this impression, namely, contact with the central jaw area. This is done by drilling a small hole of approximately nine gauge B. & S. in the centre of the impression, which allows the escape of air and excess of thin plaster in the next and final operation,—namely, the final correction with plaster, and which instantly relieves the atmospheric pressure and its strong retention.

28. THE FINAL CORRECTION WITH PLASTER, AND ITS FUNCTION.

To correct the condition described in the preceding section, and to secure the ideal condition of even contact over the entire jaw at slight additional pressure at the peripheral valve seal, a mix of the finest procurable plaster (Kerr's Snow White, for example), introduced at the consistency of thin cream, is added to the impression and the impression again returned to the mouth, with the excess passing through the hole previously drilled through the centre.

29. THE SPECIAL QUALITIES OF THE LINING MIX FOR THE HALL IMPRESSION.

Upon the judgment and skill of the dentist in the mixing and insertion at the psychological moment of this lining mix of plaster, depends the entire success or failure of the impression, for the lining mix as indicated in Fig. 21, must be of such a consistency that the peripheral valve seal should show through, leaving contact at light pressure of plaster upon the remainder of the jaw and "setting" in the mouth at about one and one half to two minutes, allowing time for adjustment, without fatigue to patient. This produces in its highest degree adhesion and cohesion by accurate contact, while the slight excess of pressure at the peripheral valve seal protects ingress of air during dislodging movements. (Section 30.)

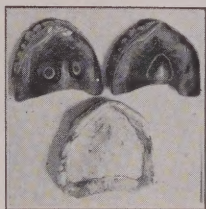


Fig. 16.—A Finished Hall "Pierce Arrow" Impression. Note the detail afforded by the properly mixed lining mix and the peripheral valve seal in Kerr's Compound, the former muscle-trim and post-dam showing through. Note difference in length beside previous unsuccessful restoration.—(Courtesy Hamilton Clinic Club.)

30. PREPARING THE PASTER FOR LINING MIX.

The plaster itself must be of first quality; as Dr. Hall has found that Kerr's Snow White Dental Plaster answers to the peculiar characteristics desired, the technic of preparing this as original with Dr. Hall, presupposes the exclusive use of the material.

Step (a) *Sieving the plaster.*



Fig. 17.—Dipper sieve for sifting plaster.—(Courtesy S. S. White Co.)

A dipper sieve or a rotary four sifter of approximately sixteen meshes to the inch is first used to catch any set particles or foreign material which may have accidentally become incorporated. This is done upon a sheet of paper, or into an extra dry plaster bowl.

(b) *The plaster bowl and water.*

A clean scrubbed bowl is necessary, of the largest size made (twenty-four ounces capacity). Into this is placed twenty-five c.c. of water, at such temperature as it leaves the hydrant, 50° to 60° F., depending on the conditions. Suitable spoons of cast aluminum may be procured from department stores or similar house-furnishing establishments, as originally suggested by Dr. George H. Wilson, holding 25 c.c. (See Fig. 18.)

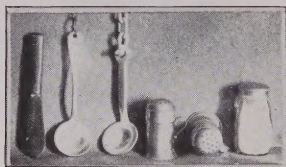


Fig. 18.—Plaster Measuring Spoons of 25cc. Capacity.

- (a) Original spoon procurable in department stores, holding 25cc., as originally suggested by Dr. Wilson.
- (b) Special design made from (a) by waxing heavier handle and having cast at a brass foundry and finished at a plaster's.

Step (c) Ordinary sugar shaker of 3 ounces capacity with 19 holes to 6 inches in cover; this is for the purpose of holding sulphate of potash.

Step (d) The ordinary sugar shaker filled with sulphate of potash is next taken and two shakes of the sulphate into the 25 c.c. of water, alternated by a movement of tapping the bottom of the shaker on the bench is used. This will release approximately 10 grams (troy) of sulphate. A saturated solution of sulphate may also be used if desired. With a wide spatula this should be mulled against the bowl until the solution is complete.

Step (e) 25 c.c. by spoon measure of sifted plaster is next sifted into the water.

Step (f) *Stirring.* Some experience is necessary, as sometimes two or three minutes stirring are required before the "clabber" condition of the plaster desired appears. The bowl is rotated by the left hand and inclined to permit closer observation, and the spatula is moved back and forth sideways in

a cutting movement as advised by Dr. Prothero. Immediately the slightest thickening of the plaster, from a milky fluid which one would surmise would never set, to a slight thickening, as cream curdling in milk, the plaster is poured into the waiting impression, previously dampened, and the impression is hurried to the mouth of the patient in the shortest possible time.

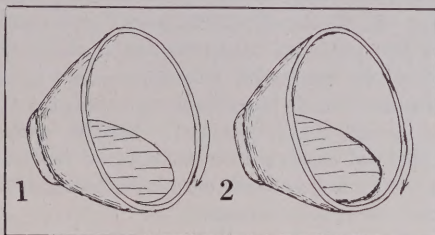


Fig. 19.—An attempt to diagrammatically illustrate the "clabber" of Kerr's Snow White Plaster in Hall's technic of lining mix.

- (1) Position of bowl when rotated with mix inside, with surfaces of milk-like consistency of plaster flat while bowl rotates.
- (2) When the milk-like plaster begins to thicken into a cream-like plaster, showing a beginning tendency to follow the rotating bowl. This is the psychological moment, and all speed is necessary to fill the impression and get it into position in the patient's mouth.

31. INSERTION OF PLASTER IN IMPRESSION TRAY.

Probably the most important point to be borne in mind at this stage is that of the proper consistency of the lining mix of plaster at the time the impression reaches the mouth. Should the plaster be any harder than the incipient crystallization, as indicated in Figure 19.

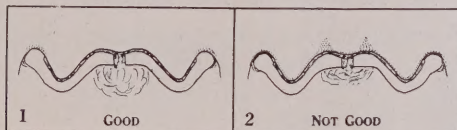


Fig. 20.—Error of inserting impression with plaster with crystallization too far advanced.

- (a) Impression with plaster lining too hard. The impression is held out from its place and the muscle-trim and post-dam, also relieve in centre of first impression entirely lost.
- (b) Impression with plaster lining too hard, but forced to place with considerable pressure, note the muscle trim periphery approaches somewhat more closely, but not sufficient, and the softer tissues are seriously displaced, rebounding against the impression with a dislodging movement, also against the denture made from such an impression. In both cases the plaster should be carefully washed or chipped out, and the plaster re-mixed and re-applied.

the muscle trim and post-dam is altogether lost and the tissue probably overstrained, and altogether lost and the plaster should be

washed or chipped out carefully, scrubbed to remove any vestage of plaster (the presence of already set plaster hastens the setting of a fresh mix) and the mix re-made and re-applied.

32. INSERTION AND TIME OF IMPRESSION.

The shortest possible time should elapse between the seating of the impression after it has been prepared with a soft plaster, with the head of the patient slightly tipped back the impression is passed between the lips with the posterior part reaching its seat a little ahead of the anterior part driving a larger portion of the excess plaster towards the mesial, the impression is gently carried to place with an intermittent pressure, which literally pumps the plaster to its place, and the excess through the hole or at the sides or back, should anything but the slightest resistance be encountered from the impression the impression should be removed, the plaster lining either washed or chipped out, and the process repeated.

As soon as the impression is "Home," which can easily be detected by its immovability, one or two light massage movements are made on the lips and cheeks to send excess downward, and pressure is immediately released and the fingers removed from the mouth. The patient is instructed to relax all mouth tissues and lean forward, allowing the saliva to accumulate in the anterior part of the mouth preventing choking, a little of the plaster in the bowl may be removed by the finger and placed upon the impression as a timer for removal, as the plaster in the impression, due to the heat of the tissues, sets more rapidly than that in the bowl, as soon as that plaster exhibits complete crystallization, which should not be longer than two or three minutes, the removal of the impression is then begun.

33. REMOVAL OF THE IMPRESSION.

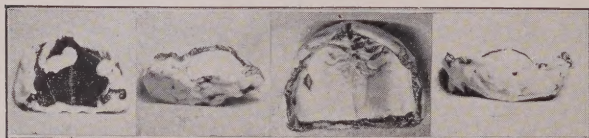


Fig. 21.—Mesial, Lingual and Buccal items of Hall "Cadillac" impression as shown in Figure . Note excess on lingual and peripheral valve seal showing through plaster.

Immediately following the crystallization of the plaster, the impression should be removed, dipped or coated with the separating medium, and the stone made, all with the least possible delay to avoid inaccuracy hereinafter described.

Quite occasionally the accuracy of this impression and the peripheral valve seal is such that the removal is somewhat difficult. The

process is begun by grasping the impression between the thumb and first finger of either one or both hands and moving the impression up and down or sideways, a slight give caused by ingress of air at one point or other on the periphery may be noted, and the dislodging movement is then directed at this point; at all times gently so as not to dislodge any of the thin plaster lining, and at the same time drawing out the cheeks to break the peripheral valve seal, particular care should be taken in case of undercuts of any size, and once the impression is free, and removed from the mouth, the patient should be instructed to remain motionless, and not empty the mouth for a moment or so, which gives the dentist an opportunity to examine the impression, and, if any small parts are broken off, to search and find these before the patient empties the mouth.

Should however, the impression not respond in the slightest degree by gentle dislodging movements, between the thumb and first finger, wet pledgets of cotton may be applied by the nurse around the periphery. This will probably prove effective, after a short while, but if not the patient is instructed to close the lips and distend the mouth with air. This will invariably dislodge the impression.

34. PREVENTING INACCURACIES AT THIS STAGE, DUE TO EXPANSION OF PLASTER.

Practically all plasters expand somewhat, beginning shortly after setting, and continuing more or less for twenty-four hours. This expansion in an impression, as has often been set forth in the literature, often results in disaster, as noted in Figure 21. Dr. Hall's entire technic in the use of plaster.

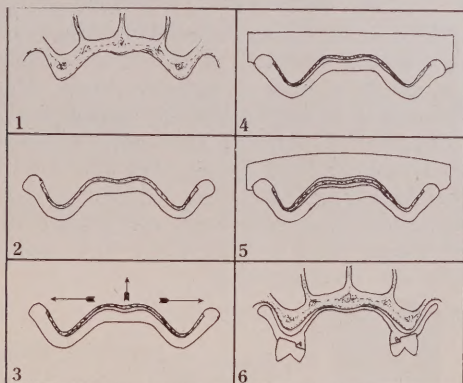


Fig. 22.—Diagrammatic illustration of error due to plaster expansion.

- (a) Section of upper mouth.
- (b) Accurate impression of ditto, immediately on removal.
- (c) Inaccuracy due to possible expansion buckling up the central plaster.
- (d) Inaccuracy of cast, dotted line shows proper contour.
- (e) Result:—denture rides in medium raphe.

Is intended to minimize this as much as possible, as noted in the following:

- (a) Very thin mix; the thinner the mix of plaster the less expansion.
- (b) The use of K2 s04. Prothero and others state that this controls the expansion of plaster.
- (c) Immediate coating of the impression, with a fast drying separating medium, and "boxing" and making of cast, after removal from the mouth. The cast is formed before an appreciable degree of expansion has taken place.
- (d) The use of a "stone" model which does not expand or contract, and is sufficiently hard to withstand the pressure of vulcanization.

35. THE HALL COLLODION SEPARATING MEDIUM.

Dr. Hall's energies have been directed in envolving a fast drying medium giving an impregnable film, which may be applied to a "green" impression evenly and rapidly, and has designed the following formula of Squibb's flexible collodion, thinned with equal parts of alcohol and Squibb's ether, colored by a sufficient quantity of gentian violet. The latter the suggestion of Professor Lancaster, of the Royal Dental College. This should be thinned down to such a consistency that, after the saliva and loose particles of plaster are gently wiped off the impression with cotton and allowed to dry until no free moisture is present when the impression may be taken and totally immersed in this solution for a second or two, lifted out and set to one side to dry, and after the excess has drained off, that no loss of fine lines is noticeable, and that a second "dip" after the first is dry may be given, also without loss of fine lines. This having been accomplished, the boxing of the impression, or the construction of a removable "form" into which the stone is poured and held until it has set is in order, care must be taken to keep the impression during this process from an open flame, as the whole is unfortunately highly inflammable.

36. BOXING THE IMPRESSION.

This may be done by taking a wooden paddle, and in the centre of it placing a cone of Harbutt's plasticine, a modeling composition obtainable in schools, or book or stationery stores. Press impression down on this cone so it will be held in desired position, surround impression with strips of plasticine, allowing it to extend from wood to the peripheral border of impression, then trim down all round till peripheral border is about 1-8 inch, higher than plasticine, fasten to wood with melted wax and wrap with a lead band about 20 gauge, which should stand up high above impression and surround with rubber band to hold in position.



Fig. 22A.—A paperhanger's seam roller, extremely useful in rolling strips or sheets of plasticine. Use cylindrical form, as above, not barrel form, as popular with paperhangers.—(Courtesy Ridgeley Trimmer Co., Springfield, Ohio.)

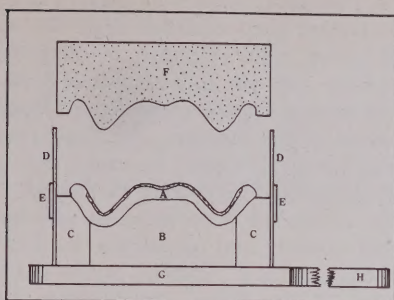


Fig. 23.—Diagrammatic illustration of "boxing" an upper impression.
 (a) Impression dipped and coated with collodion separating medium.
 (b) Cone of plasticine.
 (c) Strips of plasticine, allowing periphery to project 1-8 inch past.
 (d) Soft metal rolled to 20 gauge.
 (e) Elastic, binding altogether.
 (f) Finished model, note the shaping of the model which includes the impression of the lips and cheeks for about 1-8 of an inch past the periphery. This is called "cheek fit" is of considerable importance in securing peripheral valve seal. An ordinary paper-hanger's flat seam roller of 2" length is extremely useful in preparing sheets or strips of plasticine. Keep all wet.

37. PREPARATION FOR POURING CAST.

Soak impression in water until it has absorbed all the moisture possible, otherwise if artificial stone is poured in dry impression the moisture will be absorbed from mix and that the cast will be granular. Next, cover impression with lather made with soap and shaving brush, washing it off under the tap, this leaves a soapy film on the collodian, and assists greatly in separating. Absorb any surplus moisture with absorbent cotton, or blow off with compressed air.

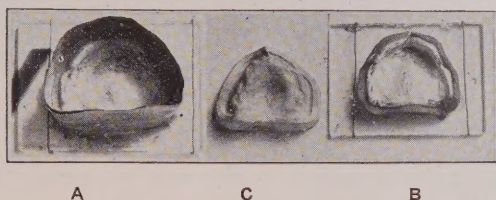


Fig. 24.—Appearance of semi-boxed impression and completed cast.
 (a) Impression supported from below with plasticine, and rim intended to reproduce "cheek fit" so called.
 (b) Boxing complete ready to pour.
 (c) Completed cast, note wide border from cheek fit.
 —(Courtesy Hamilton Clinic Club.)

38. STONES, THEIR USE, AND HYDRATION.

Prior to the appearance of Spence's plastic compound, which was the first of this series of hard material for Dental Casts to become

known to Dental Profession, plaster of paris was the only known material of which Dental casts or models might be constructed.

Then the well known faults of plaster of compressibility and expansion were, and are even yet in the hands of those who see fit to use it for casts, the source of endless trouble and disappointment due to ultimate distortion of the denture. For these reasons the writer would submit that for Dental casts, in which any accuracy is required plaster of paris should be entirely eliminated.

Spence's plaster compound is an excellent preparation of plaster of paris, Portland cement, and chemicals to control its setting. Weinstein's cast compound is a "Calcium barium silicate" compound, (*Wilson). Others, "Alston Stone" and "Dentco Stone" are compounds of fine consistency. These materials if properly handled do not expand or contract, and carry about four times the pressure of plaster. The technic of Weinstein's stone involves weighing of the ingredients according to directions, and produces a fine dense cast. The technic of the former and latter involve one 25cc spoon measures of water in the largest plaster bowl and between three or four level 25cc spoon measures of the powder.

In mixing this the three spoonfuls are emptied into the water and a vigorous spatulation with a heavy stiff spatula (Figure No. 18), until a mix similar to liquid plaster mix, (readily dropping off the end of the spatula) is secured, gradually the fourth spoonful of powder is added, while the spatulation continues, until a stiff putty-like mass is secured, which will not drop off the spatula, which requires jarring and assistance into details of impression by a mechanical vibrator and by instruments, if impression of individual teeth are present. The larger the amount of plaster incorporated in the mix, with sufficient plasticity of the mix gives the best results, setting takes place in from four to six hours.

39. MECHANICAL VIBRATORS FOR INTRODUCING STONE INTO IMPRESSION.

No well equipped Dental Laboratory should be without one of these, the simplest of these vibrators is the use of a stone, which is out of true, and preferably filled with wax or felt buff in a lathe, the work being supported upon a wooden base or paddle. Dr. Tench, suggests in this connection, a large hexagon nut.

*See Wilson text Prosthetic article, on plaster, begins page No. 69 (last edition).

A somewhat more elaborate but more efficient apparatus readily installed in a laboratory at a cost of approximately \$25.00 might be made from a piece of brass plate 14" x 6" x 1-8" bolted to a table firmly at one end by means of three ordinary carriage bolts 3-8" x 7" long, on a hardwood block 6" X 3" X 5" and

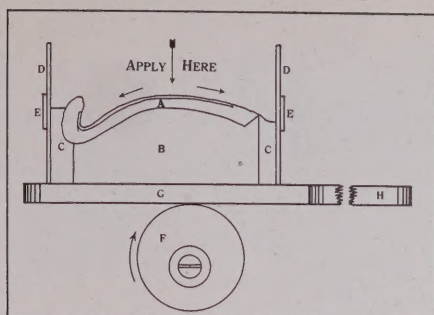


Fig. 25.—A Simple Vibrator.

- (a) A stone out of true and filled with wax, or similar, a hexagon nut.
- (b) Wooden paddle.
- (c) Boxed impression in sections.
- (d) Metal form. Arrows indicate application and direction of flow of material.

having at its free end bolted a small motor with a flat base of the Hamilton-Beach or Dumore, type and with a foot switch similar to a sewing machine motor upon the shaft, is fitted a small eccentric, made from a rod of brass 7-8" in diameter and about 1-2" in width and with a hole drilled 1-8" from the centre. This rapidly revolving eccentric vibrates the whole free end of the plate, and the apparatus is useful for impressions, also filling the largest and heaviest flasks with plaster for vulcanization (Figure No. 26).

Another suitable appliance is stocked with brass founders' and molders' supplies, for vibrating sand molds, as per illustration, and may be installed at a cost of about \$22.00 (in Canada) complete with ingenious and effective knee switch. This is used with block and brass plate as in Fig. 41 in place of the motor.

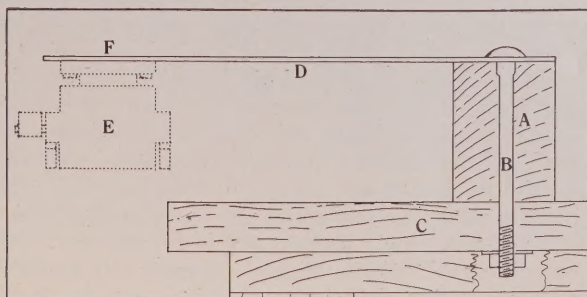


Fig. 26.—Electric Vibrator. The construction of which is described in section No. 41.

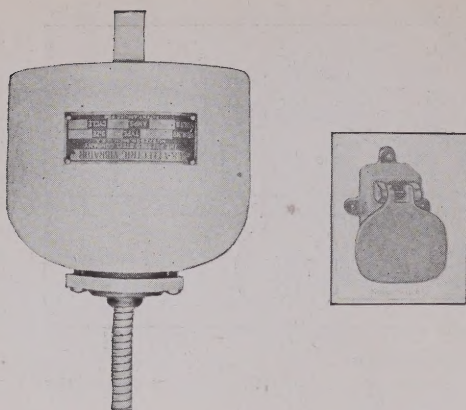


Fig. 27.—Illustration of Vibrators, used by molders and similar manufacturers, and handled by the E. Woodison Co., Toronto.

The above illustration shows the vibrator attached to a molder's box. For Dental use this should be attached on a brass plater mounted as in Figure No. 26, in the place of the motor. A lug is cast on the upper part of vibrator making this simply done. Note knee switch.

This apparatus sells in Canada for approximately \$22.00

The width of the resulting cast is predetermined by the technic in boxing, in which a plasticine rod or strips is adapted around the periphery, and the only remaining dimensions is that of the vertical thickness at the thinnest point.

The capacity of the flask used, (this should be the largest possible) is in the final analysis, the guide for the size of the model, for generally speaking the best results are secured by the use of the largest model, which, with the teeth waxed and ready to flask. This may be estimated and a little mark made in the inside of the plasticine wall to indicate the thickness of the model desired, which should not, generally speaking, be less than half an inch at the thinnest point.

Regarding the actual technic, the entire impression and boxing, lathered with soap with a shaving brush, washed out and the excess moisture blown out with compressed air, leaving a thin film of soap, as already described, the stone about as plastic as well mixed putty is picked from the plaster bowl, and in pieces about double the size of a marble inserted into the centre of the impression, with the right hand, the left hand holding the impression and boxing on the vibrator, which is set in motion by the foot or knee. Immediately the stone will flatten and will travel radially towards the margin. This process is continued until sufficient thickness of cast at its thinnest point is secured, at which time no further material is fed into the impression. The thickness is now noted by the marks previously made or by taking a "sounding" with any straight instrument.

No. 40. REMOVAL OF BOXED IMPRESSION FROM CAST.

At a time when the initial set* is complete (which varies from fifteen minutes to three quarters of an hour, at which time it is safe to remove the metal boxing only), the elastic band is removed, and the soft metal boxing gently peeled off, also the plasticine may be removed gently, at this time, the advantage of this is that the edges of the model may be easily bevelled, or carved in any way desired, the material at this stage cutting very readily.

At a period later, from one half to two hours, at which the hard set has taken place, the balance of the impression material is removed, this may best be accomplished by dropping impression and model downward, and preferably in a metal holder, in water previously brought to 180° temperature, *without* a flame beneath the container. The common practice of dropping the impression and model into water at this or a higher temperature, with a flame below, is somewhat risky, especially if the attention of the individual is drawn from the work on hand, resulting in overheating and consequent difficulty in removing impression.

41. BRIEF WORKING SYNOPSIS OF HALL "CADILLAC" IMPRESSION.

For the busy dentist this has been thought to be of value, and presupposes the patient in the chair, the examination complete, the mouth made ready for the impression, and all materials to hand, with assistance of dental nurse, or other assistant.

1. Choose and fit tray, by dentist.
2. Tray filled with compound by nurse, dentist secures first impression after check insertion.
3. Tray trimmed down buccally and lingually and below, ready for muscle trim and postdam by nurse, and completed in mouth by dentist.
4. Centre scraped and holed by nurse.
5. Clabber mix prepared by nurse, tray filled by nurse and inserted by dentist.
6. Removal by dentist, boxing and filling by nurse or assistant.

42. THE HALL "PIERCE ARROW" IMPRESSION.

This impression, while consuming more time, is superior to the impression just described in as much as the peripheral valve seal in the impression is supported instead of by black compound by a rigid special vulcanite impression tray upon which the Kerrs compound is traced immediately before the insertion of the final plaster lining mix. It involves, as stated below, a muscle trimmed and post dammed impression similar to the "Cadillac" up to the time im-

*The initial set of any material is that time when the material will support the smaller Gilmore needle of ¼-lb. weight with a point one 12th" in diameter. The hard set will support the larger Gilmore needle of one pound weight and one 24th" diameter. (See Wilson Dental Prosthetic, page 75.)

mediately before the insertion of the lining mix. Instead of however inserting the lining mix at this time, the compound tray is invested with stone or plaster and having been thinned down, is reproduced in vulcanite. The entire periphery of the special vulcanite tray is, at a second sitting, reinforced with plastic Kerr's compound stick by "tracing on," and quickly applied to the mouth. This gives a peripheral valve seal of highest accuracy, and of pressure graduated by the operator. This having been removed and trimmed, the clabber mix is then next made, and the impression completed as before.

43. INDICATIONS FOR THE "PIERCE ARROW" IMPRESSION.

This is the method which may be used in all cases in which it is desired to give the most secure adaptation, regardless of time or time-expense and also in cases in which have been failures from the impression standpoint, in cases requiring metal bases for class 1 cases (see section 11) and also cases where a tight peripheral valve seal is required to develop an undersized ridge (see Figure 3). The peripheral valve seal may be, however, easily overdone, with consequent strangulation and ridge alrophy. See Section 70.

44. MAKING THE SPECIAL VULCANITE TRAY.

Presupposing that the work described in Section 15 to Section 25 has been completed, and that, at this stage, the muscle trimmed and post-dammed impression is ready to be converted into vulcanite rather than filled with the lining mix as described in the "Cadillac" impression. This is now filled with either plaster or stone.

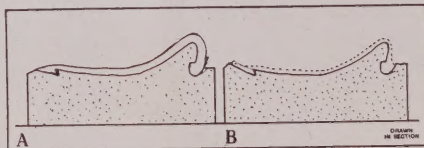


Fig. 28.—Making the vulcanite tray by direct or indirect method.

- A. The impression filled with plaster or stone.
- B. The cast secured after plaster or stone in A has set. This may be invested for vulcanization directly, if the black compound has been previously thinned with a Kingsley scraper or similar. Otherwise it might be better to remove impression and add a single sheet of wax, then invest, which is the indirect method. And the tray constructed in vulcanite either by the direct or indirect method.

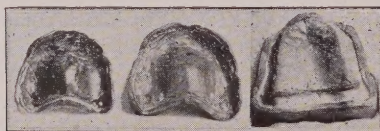


Fig. 29.—Stages in making vulcanite tray.

- A and B, before and after vulcanizing.
- C. A stone model ready for the application of sheet wax for indirect vulcanization of tray. Hole in error, not made till immediately before lining mix.

(Courtesy Hamilton Clinic Club.)

45. TRACING ON COMPOUND FOR PERIPHERAL TISSUE COMPRESSION AND VALVE SEAL.

One of the great advantages of this method lies in the fact that the entire peripheral valve seal may be fitted in one operation, because of the previously fitted rigid vulcanite base support for the peripheral valve seal material, rather than the black compound plastic support plastic at only twenty degrees of heat, above the Kerrs compound tracing material, as used in the "Cadillac" method. This makes it possible to bring the entire periphery to a uniform heat, in hot water, and by quickly inserting in the mouth in this state, a periphery valve seal of highest accuracy may be secured.



Fig. 30.—Kerr's compound "traced on" the periphery of a vulcanite tray. This is heated uniformly in a small flame, dipped in water at 160° to prevent burning the tissues, and inserted in the mouth. The above shows the hole already drilled; this is in error, as the adhesion may be better checked by leaving the hole till after the new peripheral valve has been completed. See Fig. 14.

To trace Kerrs compound on the vulcanite tray, after having been filed smooth (not necessarily polished), is dried and the end of a stick of compound heated in a small flame, also rotated between thumb and first finger. This fairly uniformly heats the end of the stick for half an inch or so, at which time the softened and almost dripping end of the stick is applied to the periphery, and also rotated. A little practice will enable the dentist to rapidly and accurately "trace on" compound in any desired thickness or width. Fig. 14.

Having quickly accomplished the tracing on of the periphery compound, it is evenly heated by immersing in hot water at 160° until the entire periphery is softened to about the consistency of, for lack of a better example, chewing gum, at which time the tray is inserted in the mouth, with massage movements hereinafter described.

46. THE PRESSURE OF THE APPLICATION OF THE PERIPHERAL VALVE SEAL OF THE IMPRESSION.

Some judgment and experience is required to gauge the pressure, the chief liability to error being too great a pressure. Heavier pressure up to say 10 lbs. are indicated in cases of hard dry ridges, especially if a slightly metal base is used, or in cases in which it is desired to force back the peripheral flexible tissues, the operator keeping well in mind the danger of strangulation. For practically all other cases lighter pressure merely sufficient to print well the contours of this flexible peripheral tissues in the softened compound are sufficient.

47. REMOVAL, HOLING, AND TRIMMING OFF EXCESS.

A surprising resistance to removal at this stage will be encountered, which is explained in Section 17, similar to the "Cadillac" impression. The excess compound about the peripheral valve seal should be trimmed to a width of about 1-8 of an inch, except the post-dam, which is approximately twice this width. A hole of about No. 9 gauge Brown & Sharpe should be drilled in the centre of the impression, which will instantly relieve the strong retention just described.

48. BALANCE OF THE IMPRESSION.

The remainder of the impression consists in moistening the tray, also the valve seal, applying the lining mix as described in Sections 30 and 31, inserting with the pressure governed by consideration described in Section 46, removal, boxing, coating with separating varnish, and making the cast as described in Section 33.

49. BRIEF SUMMARY HALL "PIERCE ARROW" IMPRESSION.

The first four steps and the last two are identical with the "Cadillac" impression, and are as follows:

1. Choose and fit tray by dentist.
2. Tray filled with compound by nurse, dentist secures first impression after check insertion.
3. Tray trimmed down buccally, lingually and below ready for muscle trim and post-dammed by nurse, and completed in mouth by dentist.
4. Centre scraped and holed by nurse.
5. Make special tray of vulcanite, add new peripheral valve seal with Kerr's stick compound.
6. Clabber mix prepared by nurse, filled by nurse and inserted by dentist.
7. Removal by dentist, boxing and filling by nurse or other assistant.



Fig. 31.—Two Hall "Ford" impressions. This is a rapid impression made by a single insertion of black modelling compound, edges thinned, with or without muscle trim or post-dam, and a single lining mix of plaster, with or without an escape passage. The most rapid of the Hall series (15 minutes) and suitable for a large number of conditions.—(Courtesy S. S. White Co.)

50. THE HALL "FORD" IMPRESSION.

This is the most rapid of the Hall series, consuming ordinarily about fifteen minutes, and may be used in a large number of Class 2 cases (see Section 12,) in which time and expense may be a consideration. It is less suitable for cases of any particular difficulty because the peripheral valve seal is not carried to as accurate an adaptation in previous methods, as will be noted, but the safest impression from the standpoint of strangulation of the tissues.

51. SECURING THE FIRST IMPRESSION, AND ITS PREPARATION FOR THE LINING MIX OF PLASTER.

This process is identical with that described in Sections 15 to 20 up to the point of beginning the muscle trim and post-dam, leaving an impression with a semi-massage margin, and trimmed approximately to the contours of the finished denture. Depending upon the circumstances, the operator need not further muscle trim or post-dam, but should satisfy himself that the margins are approximately slightly less than the correct heights, and that the impression extends at least 1-8 of an inch on the moving soft palate, the centre may or may not be scraped, but it is advisable, and also the relief passabe for plaster of No. 9 gauge B. & S., is quite unnecessary.

52. COMPLETING THE IMPRESSION.

The lining mix is added as already described, although a somewhat smaller amount than either of the other two methods, because of the lesser removal of the black impression material, also lighter pressure for fear of displacing soft tissues, and also a somewhat softer mix of plaster. Boxing and pouring of cast as already described.

53. BRIEF SUMMARY OF STEPS HALL "FORD" IMPRESSION.

These are as follows:

1. Choose and fit tray, by dentist.
2. Tray filled with compound by nurse, and applied to mouth by dentist.
3. Tray trimmed down buccally and lingually by nurse sufficiently low to allow for plaster periphery without tissue.
4. Lining mix inserted by nurse, insertion and removal by dentist, making cast by nurse or other assistant.

54. HALL LOWER IMPRESSION.

Since human teeth have been lost, and full lower dentures have been made, has the full lower denture been a problem, because of its comparatively small area of adhesion and constant displacing movement by the tongue and cheeks. While Dr. Hall does not

assume that this system will give full lowers adhesion as in uppers, yet, the technic he suggests and the theory upon which this is based leads in most cases to surprising results and in a few, adhesion similar in efficiency to the upper.

55. THE RETENTION OF THE FULL LOWER DENTURE.

The scheme of retention of full lower dentures is that or, so far as is possible, adhesion, over as large an area as possible, between the film of capillary aerated saliva between the base and the mucoosa, and cohesion in the substance of the saliva itself. Peripheral valve seal, aiding in securing a tidal vacuum, is sought after, but is usually difficult because of the loose and highly mobile character of the more especially the peripheral flexible tissues adjacent to the tongue. All of the above is somewhat aided by gravity.

56. EXAMINATION OF THE LOWER MOUTH.

Based on material in Section 9 to Section 12, both an ocular and digital examination should be made, with the tongue in a raised and lowered position, the digital to estimate approximately the amount of pressure or peripheral valve seal these loose tissues will carry. Also a digital examination in the closed position in the mouth, in the buccal and lingual mouth to note, as far as possible, the positions of the muscles during stress, all of which assists the dentist to form in his mind's eye an outline of the future denture covering as much area as possible, with peripheral valve seal yet avoiding all contracting muscles.

57. FITTING THE TRAY.

Having this in mind, a lower tray is chosen and fitted, as large as possible and preferably an 18 or a 19 because of the long lingual flange at the position of the Mylo-hyoid ridge, a part which should be covered if at all possible, and covering as large an area as possible up to about 1-8 of an inch short of the peripheral valve tissue. This may be best done with the operator standing as far as possible directly in front of the patient within easy reaching distance, and with the elbow about on a level with the patient's mouth.

58. APPLYING THE MATERIAL TO THE TRAY AND INSERTION.

Somewhat different in detail is the manipulation of the material for the lower, as described in Section 16. The preparation is identical up to the stage of the ball rolling upon the middle fingers (see Section 16), but having driven all the creases below, the thumb, index, and middle finger of each hand are stretched out straight, and by pressing these against the plastic material, it is elongated into the form of a square rod about four inches long and approximately 3-4

inch by 3-4 in. in sections. This is bent to the form of a tray, lying on the bench with the handle down, and by a wiping motion of the first finger and thumb, secured to it, the thumb lapping the material over the flange of the tray around its entire circumference to prevent its dislodgment during the impression, but allowing its easy removal after the impression. The impression is now passed over the flame and dipped in water at 160° to prevent burning.

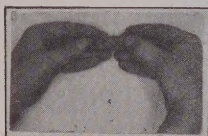


Fig. 32.—Position of finger and thumb in shaping square rod for lower impression.

It may be seen that pressure exerted will naturally develop a square rod of the plastic compound. (B) Adapting square rod to tray.

59. INSERTION, CHECK IMPRESSION, AND IMPRESSION.

From the position named in Section No. 57, the impression is inserted, right heel first, with or without a mirror, similar to that described in Section 17, and with the handle of the tray directly below the patient's nose as a guide, and the middle finger and the thumb of each hand respectively on the centre of the flange and under the chin of the patient, leaving the handle clear, a light print is made for checking. The impression may either be lifted out of the mouth bodily, or tipped up sufficiently to check the impression for centring, and if correct, with the thumbs and middle fingers as above, the impression is gently carried to place, leaving a thickness of at least 3-16 of an inch at its thinnest point, at which time the patient is requested to protrude the tongue, and then swallow if possible, object to approximately form the entire lingual margin.

60. MASSAGE OF THE MARGIN AT THIS STAGE.

Immediately after the impression is home, keeping the index finger merely touching the impression, the thumbs are drawn up from under the jaw, and a massage, directed as to pressure and direction similar to that described in Section 18-18 is done. The thumbs will readily cover the whole of the anterior two-thirds of the impression, and should it be difficult to reach the posterior third, the position may be reversed and the massage completed with the middle finger, with the thumbs resting lightly on the upper surfaces of the flanges of the impression tray. Subsequent to this the impression is removed. The object at this stage is to secure an impression if anything a trifle too large, for subsequent reduction by manipulation. (See Fig. 33.)



Fig. 33.—Position of the hands of operator and of the face of patient in massage of margins of lower impression. See Sections 18 and 19.

61. TRIMMING AND PREPARING FOR MANIPULATION UPON THE PERIPHERY.

Due to the more fragile form of the lower impression, it is wise to do as much thinning as possible to the periphery of the impression while it still remains in the tray. The requirements are to thin the margin for subsequent massage, and muscle trim, and not over the crest of the periphery as in Figure No. 11, but to a rather finer edge, because of weaker tissue action. After the lower impression is released from the tray it may be strengthened by bending a piece of No. 18 gauge wire to its approximate form, heating it approximately to 160° and dropping it into the substance of the impression material.

62. MUSCLE TRIM OF BUCCAL AND LABIAL BORDER.

This is largely a correction of the massage movements with the impression (now without the tray) as described in Section 22 and 23, and consists of warming the margin and carrying the material to the lips and cheeks to a position where it exerts a valve fit upon the entire flexible peripheral tissues identical with the upper condition shown in Figure No. 7.

63. MUSCLE TRIM FOR MASSETER MUSCLE.

Frequently this muscle will engage upon margin of the impression, and the impression at this stage must be warmed at its buccal distal half, inserted and the patient instructed to close gently, the dentist having both thumbs upon the impression. This causes the muscles to contract, and leaves the middle fingers free to massage the margin, keeping it in a position of valve fit against this muscle.



Fig. 34.—First adaptation of compound to tissue.

Immediately preparatory to making the individual tray, note material lapped over border of tray.—(Courtesy Hamilton Clinic Club.)

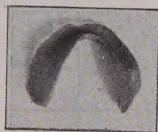


Fig. 35.—Compound tray removed from impression tray and trimmed for muscle trimming.—(Courtesy Hamilton Clinic Club.)

64. MUSCLE TRIM, LINGUAL ANTERIOR HALF OF LOWER IMPRESSION.

This may be done by softening the thinned margin of the impression over a fine flame, quickly reinserting and asking the patient to touch the roof of the mouth with the tongue. This will probably turn back some of the material at the edge, especially to accommodate the frenum. If no material is turned back, then there is a deficiency and Kerrs compound should be traced on until it does turn back, which should have ample space to move, with of course valve contact. It may be necessary to reheat at this point of the frenum to secure this, after each heating and muscle trimming, the wet fingers should be passed across this part of the margin of the impression, depressing it into contact with the floor of the mouth, as the raising of the tongue almost invariably turns up the margin at this point.

65. MUSCLE TRIM, POSTERIOR HALF OF LOWER IMPRESSION.

This may be done to soften both distal lingual halves (together), and inserting quickly asking the patient to close and swallow. This should turn up the material, and if it does not more should be added till it does turn up. This operation will give a very definite though probably incorrect form to the impression at the mylo-hyoid ridge, which is corrected at the next stage.

66. CORRECTION AND RELIEF AT MYLO-HYOID RIDGE.

A little careful handling of the impression at this stage will prevent almost certain chafing, because the posterior muscle trim just described will almost always turn the material beside, below, and

slightly under the mylo-hyoid ridge, attaching the mylo-hyoid muscle, part of the so-called floor of the mouth. By trimming this on the inner side in such a manner as to allow the plaster of the lining mix to secure the impression of this in repose this difficulty will be eliminated as in Figure No. 36.

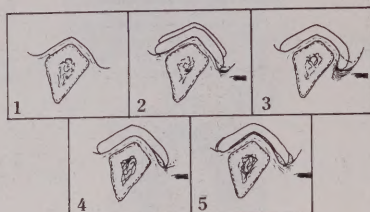


Fig. 36.—Relief of lower impression for Mylo-hyoid muscle.

1. First impression likely past the mylo-hyoid ridge, but much turned away from it.
2. Swallowing against softened margin turns the impression beside and partly beneath it. If denture is made in this form severe chafing will result.
3. Trimming of compound off the inner side relieving this altogether.
4. The lining mix then receives the contour of this tissue that rests, which will probably not chafe this part.

67. PREPARATION OF LINING MIX, INSERTION AND REMOVAL.

This process is identical with the upper, except that a trifle more plaster than one to one is used, perhaps a spoon and a quarter. This gives a slightly thicker mix, which is desirable to counteract the dissolving tendency of the saliva, and requires the same pressure to seat as the upper because of the smaller area. The impression is seated by an intermittent motion, the patient is instructed to protrude the tongue and return it to place, and the impression is then let go until the plaster has reached a state of crystallization, at which time it is gently removed.

68. APPLYING COLLODION, BOXING, FILLING AND SEPARATING.

After removal from the mouth, the loose fragments and saliva are carefully wiped off with cotton, and the impression is given a double dip in collodion as described in Section 35, standing it heels downward and upright, for drying. The boxing is very similar to the upper, except that the space between the flanges is first fitted with plasticine rolled to a sheet of about 3-16 in. thickness, cut to the approximate form, approximately fitted and with thumb and first finger carefully expanded to place. Owing to the more fragile character of the lower impression this should now be supported with a mix of plaster. The balance of the boxing and filling and separating is identical with the upper, Figure No. 37.

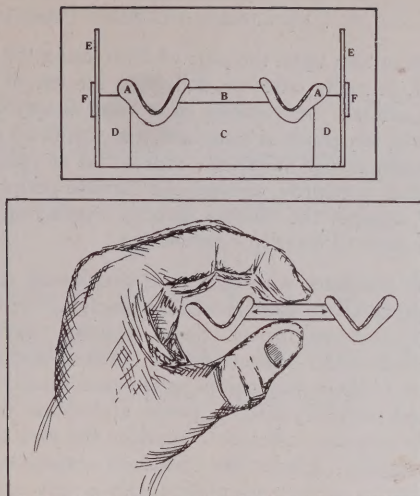


Fig. 37.—Boxing for full lower impression.

The main point of difference between the boxing for lower and upper Figure No. 19 is the plasticine sheet which

A. Is cut to approximate form and expanded by pinching against the side of the lower impression, and is supported first by plaster.

B. After which the boxing is completed same as the upper.

Removal of the boxing after initial set, trimming and final removal after hard set is identical with the upper. See section 40.

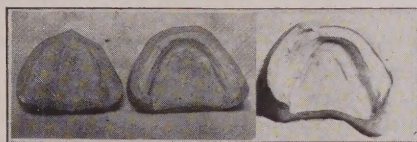


Fig. 38.—A and B showing an ideal upper and lower casts developed by technic herein described.

C. Case of a lower denture exhibiting unusual adhesion, quite as much as a good average upper made upon above principles.

69. BRIEF SUMMARY OF STEPS, FULL LOWER.

These are as follows, examination being complete, everything made ready.

1. Fit tray, wide as possible, allowing 1-8 of an inch for material past tray.
2. Apply material to tray, insert, examine to check centring, reinsert, with massage.
3. Trim, remove from tray, complete trim, reinforce with wire.
4. Massage and muscle trim, buccal and labial borders.
5. Muscle trim anterior lingual half.
6. Muscle trim posterior lingual half, trim for mylo-hyoid.
7. Lining mix, insert remove, dip in collodion, box, pour, separate.

70. AVOIDING EXAGGERATED BORDER PRESSURE.

A natural enthusiasm upon the part of those using the above methods has resulted, in many cases of, following the use of the "Pierce-Arrow" and "Cadillac" impressions, of a most disappointing loosening of the dentures, in periods of time from a month to six months. The reason has been practically uniform,—and is that of exaggerated border pressure, either outwards, against the flexible peripheral soft tissues, or inward, against the mucosa directly overlaying the alveolar process itself, or both of these in combination.

Naturally this interferes with the blood-circulation, and also with nutrition through disturbed trophic nerve function, resulting in ultimate atrophy of tissue and loss of tissue contour and consequent adaptation and adhesion. Hence, during the final application of the "clabber" plaster to these impressions, great care should be taken not to drive the raised periphery into the tissues and almost imbed it there, but to use a light pressure sufficient to produce the very slightest additional border pressure. Under the combined enthusiasm of the patient and operator for a close adaptation, this is very apt to be done, but may be avoided,—and the patient should be warned of this possibility;—the change of shape of noses from eye-glasses, and the loss of hair (alopecia) from tight hatbands being somewhat of similar character.

71. THE CHOICE OF METHOD AND CONCLUSION.

Recalling the concluding sentence of a paper read before the National Dental Association, 1921, (For paper in full, see National Dental Journal, an early issue) "a well adapted denture, without compressing tissues, that fits *moderately* well, has proved the desirable plan in the practice of the essayist, and he has found himself returning more and more to the original impression technic given in the straight compound tray and plaster without peripheral pressure and post-damming. (Ford impression).

Dr. Hall has further stated that slight peripheral border pressure has a place in special cases as so-called "treatment cases," or those in which as in Fig. 3, in which a ridge is practically developed from its overlying soft tissue by border pressure, or in cases in which for psychological or other reasons a tight adaptation is required, which may or may not be more or less temporary, that the first named impressions have a very definite place;—but that, in his opinion, a much more extensive use should be made of the simpler impression, by reason of its comparative safety from atrophic sequelae, even if of more moderate tightness of retention;—which is a matter for congratulation in a sense, bringing the prospect of good dentistry, for a larger number, with adequate reward for the dentist and at moderate fees for the patient somewhat less remote.

The Dentinal-Cemental Junction

(Bulletin Number Three)

Histological and Histo-Pathological Studies of the Dental Pulp

(Bulletin Number Four)

Harold Keith Box, D.D.S., Ph.D., F.A.A.P.
TORONTO



Bulletins Number Three and Four

ISSUED BY

The Canadian Dental Research Foundation

May, 1922

The Dentinal-Cemental Junction

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Royal College of Dental Surgeons, Toronto.

THE object of this bulletin is to demonstrate a simple but extremely important histological fact, that the canal system of the cementum stands in direct communication with that of the dentine.

The cementum may be defined as a thin, hard substance, which is a product of the cementoblasts of the pericementum, and which forms an external covering of the roots of the teeth of man and many animals. Overlying the dentine and beginning at the amelo-cemental junction, it extends to the apex of the tooth. It is the softest of the calcified dental structures. In childhood it is always thin, but it increases in thickness with age. It is laid down in layers or lamellae which are always thin on the gingival portion of the root and thicker toward the apex.



Fig. 1.—Cemental lamellae.

Generally speaking, cementum can be divided into two types, differing greatly in relation to their cell contents.

The first type, which we shall term the non-cellular, is represented in the cementum of the gingival third and usually part, if not all, of the middle third of the root. The second or cellular type is found in the apical third, and only occasionally, part of the middle third. This division is based on the writer's findings that cemental lacunae, containing cement cells, are rarely present in the gingival third, occasionally in the middle third, and are practically constant in the apical third, where they also occur in by far the greatest numbers.

Non-cellular cementum is generally, to all appearances, structureless. As stated previously, it does not contain any cemental lacunae and therefore no cement corpuscles. This type of cementum in man normally measures in thickness from 150 to 250 microns.

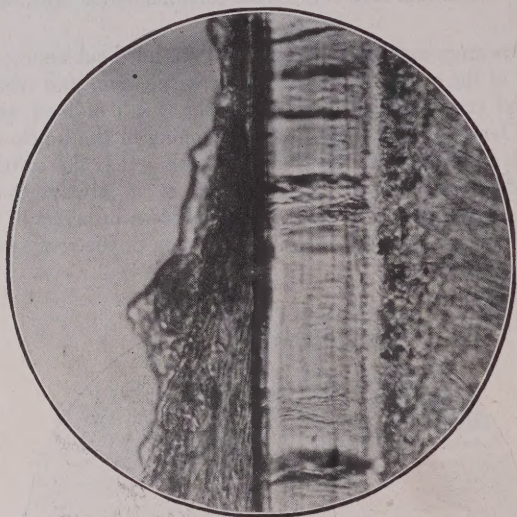


Fig. 2.—Non-cellular cementum.

In the cellular cementum, radiating from the lacunae in all directions, are numerous fine channels which branch and subdivide as they extend into the cemental matrix. These are known as canaliculi. They anastomose freely with those from adjoining lacunae and they also maintain a communication between the lacunae near the surface and the pericementum. In the cemental lacunae are found cells, termed cement corpuscles, fine projections from which extend into the canaliculi, bringing each cemental cell in close relation to a certain zone of matrix over which it has control. The cement corpuscles

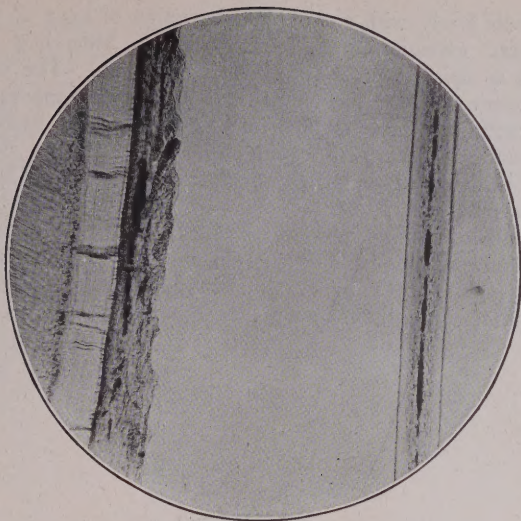


Fig. 3.—Non-cellular cementum and a human scalp hair. Non-cellular cementum is extremely thin, from a clinical standpoint, and in this instance, of the same thickness as the scalp hair.

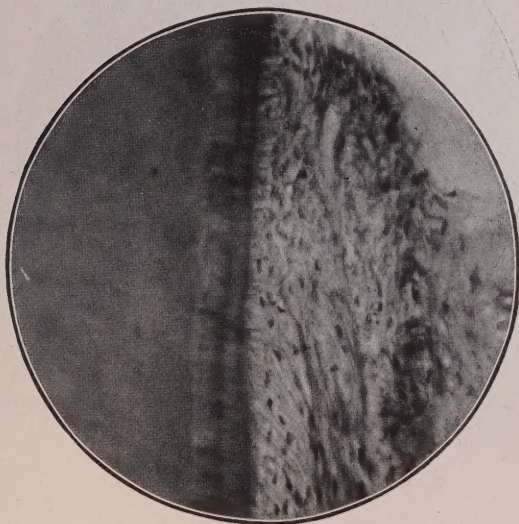


Fig. 4.—Non-cellular cementum, showing the insertion of the pericemental fibres.

communicate freely with one another by union of some of their fine protoplasmic extensions, the other offshoots extending into the canaliculi as delicate processes of variable length. The corpuscles in the lacunae near the surface of the cementum, by means of some of their extensions, seem to be joined to protoplasmic bodies in the pericementum. There is, then, in cellular cementum a continuous network of living protoplasm throughout its matrix. The cement corpuscles and their processes should be considered as being continually bathed in lymph plasma. This plasma circulates throughout the lacunae and canaliculi which form an inter-communicating network of lymph spaces similar to that found in bone. The nutrition of the cement cells and the matrix is thus insured.

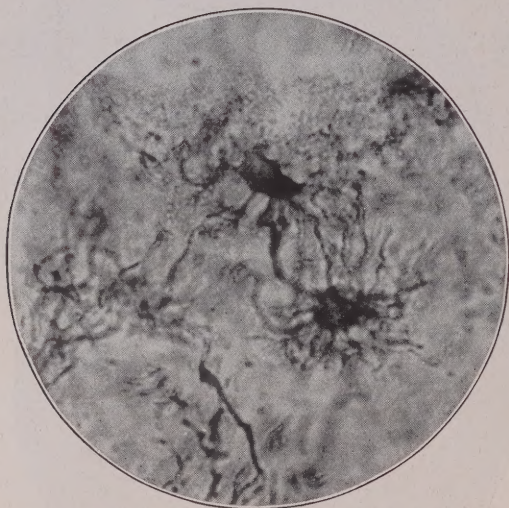


Fig. 5.—Cellular cementum, demonstrating cemental lacunae near the surface. Note the canaliculi radiating from the lacunae; also that the canaliculi of neighboring lacunae anastomose freely.

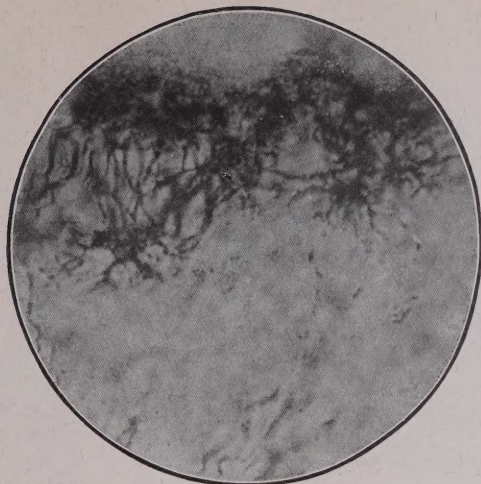


Fig. 6.—Cellular cementum, showing canaliculi of cemental lacunae near the surface, extending to the surface of the cementum; also the anastomosis of the canaliculi of neighboring lacunae.

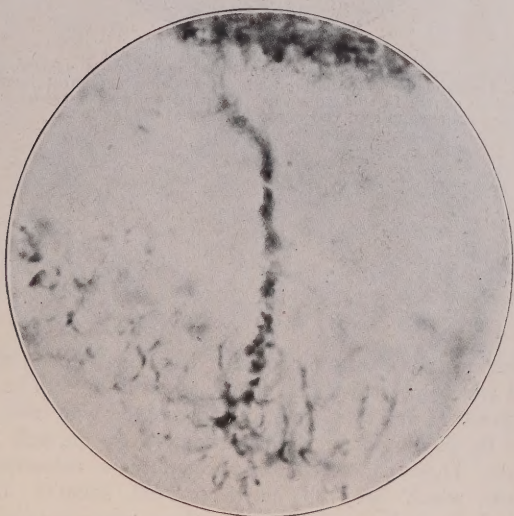


Fig. 7.—Cellular cementum, showing an extremely large and long passage extending from the pericementum to lacunae.

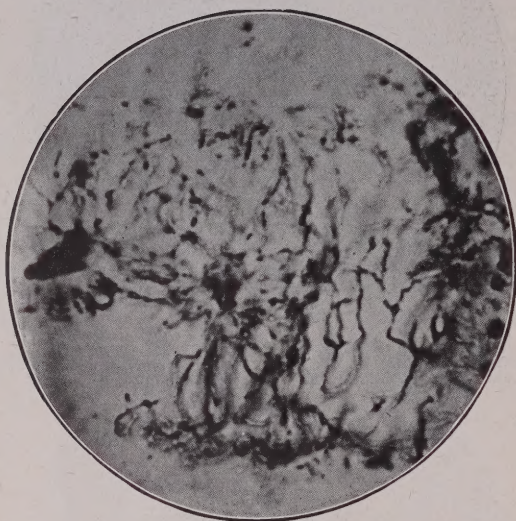


Fig. 8.—Cellular cementum. Note the uninterrupted canal system formed by the anastomosis of canaliculi of neighboring cemental lacunae. The lacunae shown in this figure are situated midway between the surface of the cementum and the dentinal-cemental junction.

The dentine is the substance which constitutes the bulk of the tooth and which gives to it its characteristic shape. The mass of dentine consists of an organic matrix impregnated with lime salts and permeated by parallel canals which radiate from the pulp cavity to the surface. These canals contain protoplasmic extensions of the odontoblasts, which are tall columnar cells situated along the periphery of the pulp, and at their pulpal extremities for a short distance, the neurofibrils from the pulp.

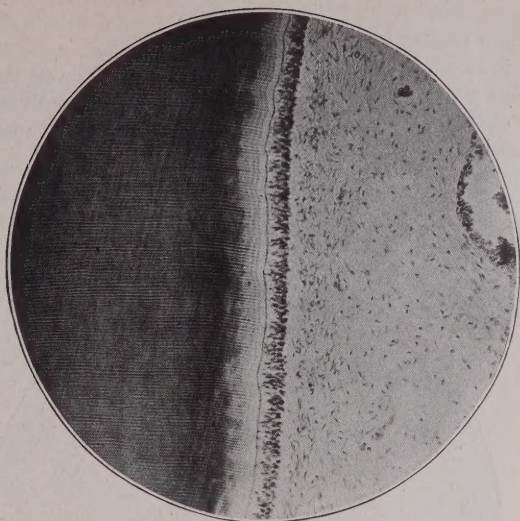


Fig. 9.—Odontoblasts.

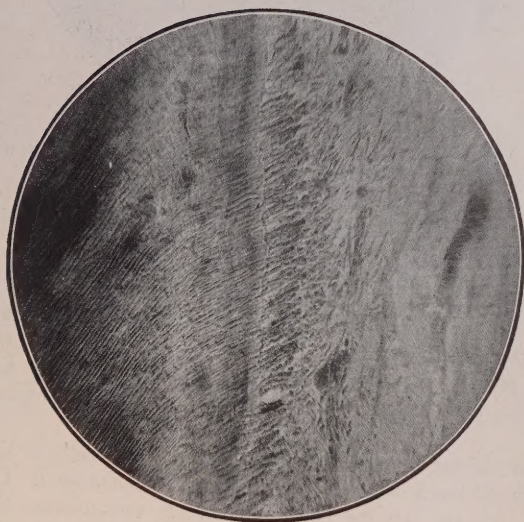


Fig. 10.—Odontoblasts.

The matrix seems to be a homogeneous translucent substance. Von Ebner, who is responsible for the demonstration of a stroma of connective tissue in bone, believes, as does Mummery, that in dentine there is also a fine connective tissue stroma. Mummery showed that at the periphery of the pulp, certain connective tissue fibres could be demonstrated passing from the pulp into the dentine matrix, and to them he gave the term "odontogenic fibres."

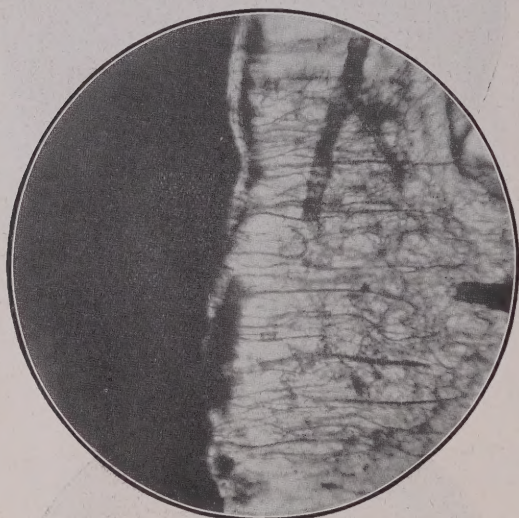


Fig. 11.—Odontogenic fibres. These connective tissue fibres pass from the pulp into the dentine matrix.

When the intertubular matrix has been subjected to the action of strong acid for some days, a transparent material remains, which, when examined microscopically, proves to be a collection of isolated sheaths or tubes. They are known as the "dentinal sheaths of Neumann" because of that writer's careful study and description of them.

When stained by silver nitrate, Golgi's rapid method, the sheaths are rendered black while the matrix remains unchanged. This would seem to indicate that the zone immediately surrounding the canals differs from the matrix in the degree of calcification.

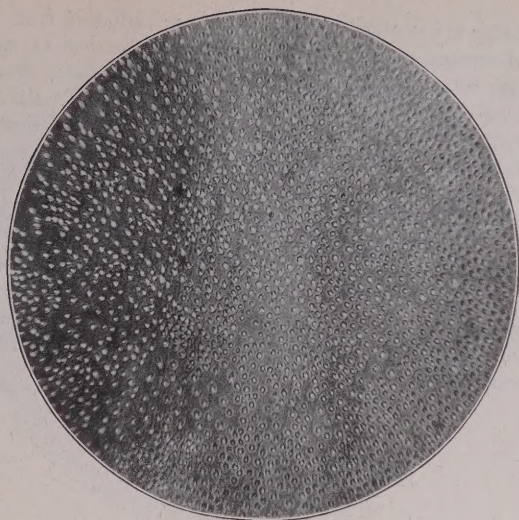


Fig. 12.—Dentinal sheaths of Neumann.

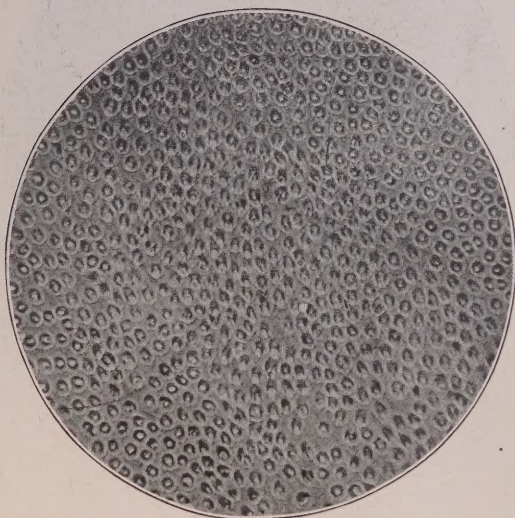


Fig. 13.—Dentinal sheaths of Neumann.

Penetrating the dentine in every direction, radiating from the pulp cavity and extending to the outer periphery of the dentine, are countless numbers of small tubes. The calibre of these tubes decreases as they proceed outwards. In the coronal and gingival portions of the dentine, each tubule describes in its course to the amelo-dentinal and dentinal-cemental junctions marked curves which are known as the primary curvatures. The course is not direct, as numerous small spiral turns can be seen on each tubule. These are called the secondary curvatures. An enormous number of tiny branches are given off from the main tubules, particularly in the dentine of the root. These small twig-like branches anastomose freely, providing a continuous network of passages in the dentine. In the crown these lateral branches are not so plentiful. At the amelo-dentinal junction the tubules branch dichotomously.

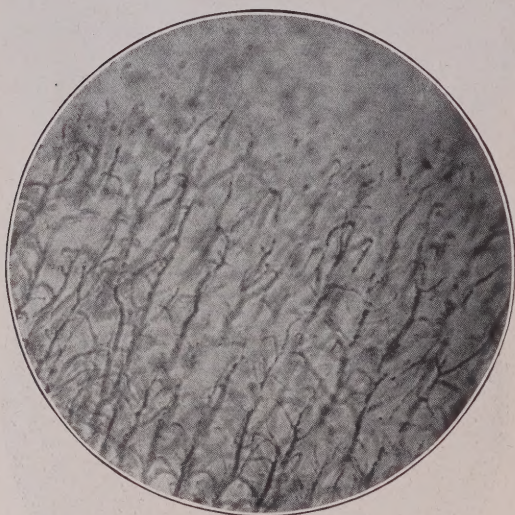


Fig. 14.—Dentinal tubules.

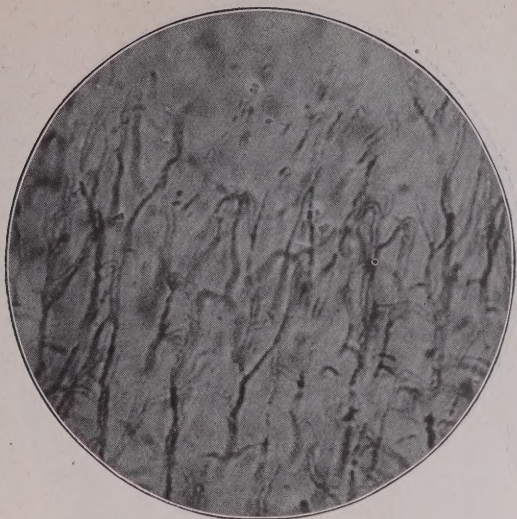


Fig. 15.—Dentinal tubules.



Fig. 16.—Dentinal tubules. This figure is a typical example of the anastomosis of the fine branches of the main tubules.

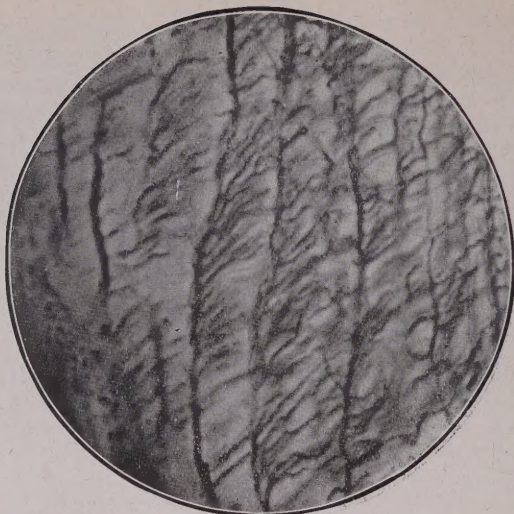


Fig. 17.—Dentinal tubules and their fine lateral branches. This figure demonstrates the enormous number of tiny branches given off from the main tubules.

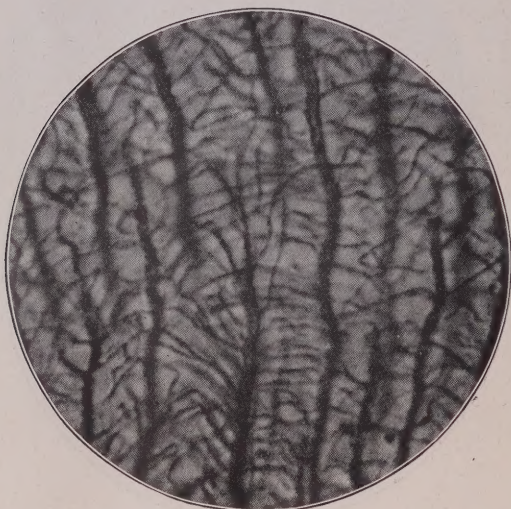


Fig. 18.—Dentinal tubules and their fine lateral branches. These small twig-like branches anastomose freely, providing a continuous network of passages in the dentine.



Fig. 19.—Spindle-shaped enlargement at ending of a dentinal tubule.

Extending from the odontoblasts on the surface of the pulp and entering the dentinal tubules, are fine cytoplasmic processes known as dentinal fibrils. Modern histological methods have made the demonstration of these fine prolongations of the odontoblasts a comparatively simple matter. Their existence was first demonstrated by Sir John Tomes. This noted dental investigator proved that these fibrils are soft uncalcified structures, a fact which made his discovery outstanding.

Previous to this time, it was generally thought that these odontoblastic projections were calcified and rigid. In sections where the pulp is torn away from the surface of the dentine, the dentinal fibrils may be seen stretching from the odontoblasts into the pulpal openings of the dentinal tubes. Owing to their extensibility, they are partially drawn out from the tubules and lengthened somewhat, before severance takes place.

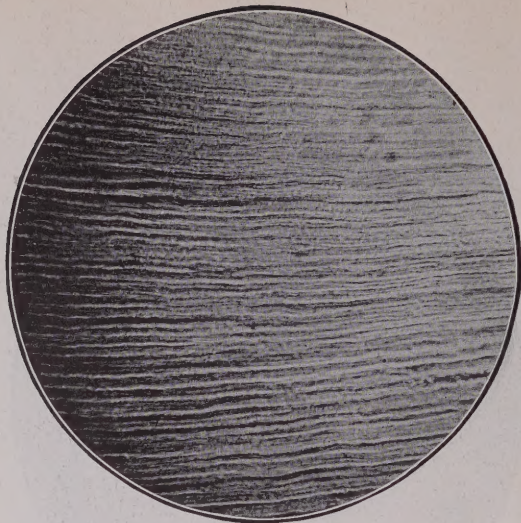


Fig. 20.—Dentinal fibrils.

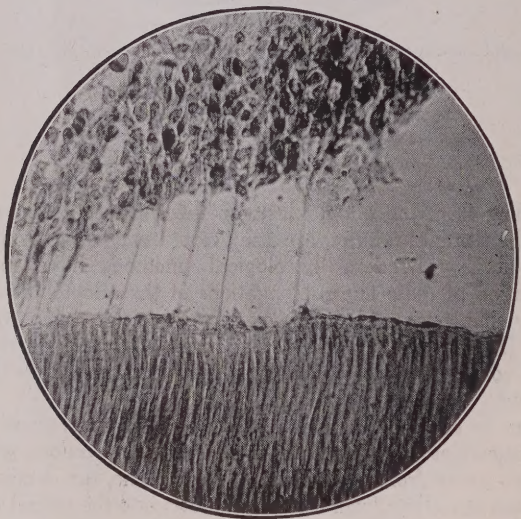


Fig. 21.—Dentinal fibrils. The pulp is torn away from the surface of the dentine and the dentinal fibrils may be seen stretching from the odontoblasts into the pulpal openings of the dentinal tubes.

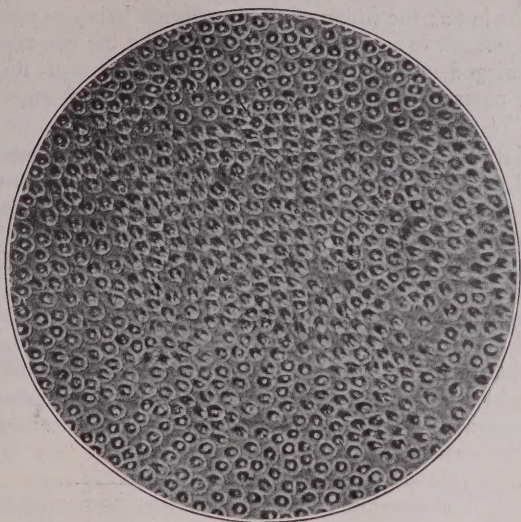


Fig. 22.—Dentinal fibrils. This figure shows a cross-section of dentine, and dentinal fibrils may be seen in the dentinal tubules.

As stated previously, the object of this bulletin is to demonstrate that the canal system of the cementum stands in direct communication with that of the dentine. It has been shown above that in the cellular cementum there is an uninterrupted canal system formed by the anastomosis of the processes of neighboring cemental lacunae, and that this system is connected with the pericementum by means of some of the fine canaliculi of the outer lacunae. Also, that in the dentine, there is a continuous network of passages, provided by the interconnection of enormous numbers of fine lateral branches given off throughout the course of each dentinal tubule. This system is, of course, maintained in direct connection with the dental pulp. These cemental and dentinal systems are not completely separated from each other by the zone of homogeneous dentine and cementum which has been considered by some investigators to constitute an impasse to inter-communication.

The diversity of opinion of noted investigators on this subject prompted the writer, some years ago, to undertake further intensive

work. It will be pertinent at this time to quote some of the opinions which have been advanced on this point.

Charles Tomes:—"The cementum is very closely, indeed inseparably, connected with the dentine, through the medium of the granular layer of the latter; the fusion of the two tissues being so intimate that it is often difficult to say precisely at what point the one may be said to have merged into the other. And, in this region there is an abundant passage of protoplasmic filaments across from the one to the other."—(*A Manual of Dental Anatomy*.)

Bodecker:—"The living matter of the cementum is uninterruptedly connected with that of the periosteum, and continues with the living matter of the dentine, either through intervening protoplasmic bodies in the interzonal layer, or directly with the dentinal fibres."—(*Anatomy and Pathology of the Teeth*.)

Noyes:—"Most authorities state that the spaces of the granular layer communicate with the canaliculi of the cementum as well as the tubules of the dentine. This the author has been unable to confirm. On the other hand, the granular layer seems to be separated from the cementum by a thin layer of dentine, and is apparently structureless. This is separated from the cementum by a dark line and the first layer of the cementum usually does not contain any lacunae or canaliculi."—(*Dental Histology and Embryology*).

Black:—"The cementum so far as has been demonstrated receives no sustenance whatever through the dentine." "Cementum is dependent on the peridental membrane for the maintenance of the life of the cement corpuscles." "When stripped of its peridental membrane, it becomes a dead tissue, no matter if the pulp of the tooth is alive."—(*Special Dental Pathology*).

Hopewell-Smith—Referring to the contents of the granular layer, states: "Their contents, according to Bodecker are soft protoplasm which is in connection with the contents of the tubules on one side and the canaliculi of the cemental lacunae (when they exist) on the other. It would seem, however, that it is by no means easy to prove this assertion. The granular layer is stained with the utmost difficulty by the action of carmine or any other basic, acid or aniline dyes. It is more likely to be beyond the pale of nutrition."

"There is, therefore, under healthy conditions, no chain of living matter joining the pulp to the periodontal membrane."—(*The Histology and Patho-Histology of the Teeth*).

Andrews:—"The cementum is thus seen to be a more or less laminated bone matrix, containing exceptionally large bone corpuscles, with numerous canaliculi anastomosing, with others or with the dentine, through, but not with the interglobular spaces of the dentine edge near the cementum."—(*The Development of the Teeth, and some of the contested points in regard to their development*

and structure). *The Journal of Dental Research*, Vol. 1, No. 3, Sept., 1919.

A number of histologists believe, then, that primary cementum, which is the layer in contact with the dentine, extending from the amelo-cemental junction to the apex, exists as a solid, dense and nearly structureless zone of calcified basic substance, and which forms a barrier making impossible any connection between the cemental lacunae and the dentinal tubules. From an examination of the majority of ground sections this statement would appear to be true. Any communication from a cemental lacuna to a dentinal tubule or to a process from one of the irregularly-shaped cavities in the granular layer, would take place through a canaliculus from a cemental lacuna. This canaliculus is an extremely fine process, corresponding in size to one of the delicate lateral branches of the dentinal tubules. This connecting canaliculus, therefore, would necessarily be involved in the process of deposition of the first or basic layer of cementum which, in the ground sections, appears to be homogeneous. Very few, if any, ground sections show to advantage the numerous minute branches which emanate from the dentinal tubules and join them to each other.

It was evident to the writer that if any advance were to be made in the study of these tissues, a different and improved technique in the preparation of sections must be evolved, a technique which would reveal the true appearance of these delicate structures. It has often been stated that sections made from chemically softened specimens do not exhibit the dentinal tubules and their branches as well as ground sections. This has not been the case in the experience of the essayist. As stated before, a lacuna can have a connection with the dentine only through one or more of its canaliculi, therefore, since most of the findings of investigators in this field have been based upon the use of ground sections, it will readily be seen that canaliculi crossing the zone of more or less homogeneous tissue might fail to be observed. The same technique used by the writer in demonstrating the extremely fine branches of the dentinal tubuli, as seen in figures 14, 15, 16, 17, 18, 19, 20, was applied to the study of this particular problem.

Instead of finding a tissue of no apparent structure intervening between the cellular cementum and dentine, the following fact was observed. Communication between the cementum and the dentine does exist, and occurs in three ways. First, the fine extremities of the dentinal tubules may have anastomosis directly with the canaliculi of the cemental lacunae. Second, the dentinal tubules often terminate join the canaliculi of the cemental lacunae. Third, pear-shaped, club-shaped or irregular spaces in the granular layer on the border of in spindle-shaped enlargements, from which fine processes extend to

the dentine have direct connection with the dentinal tubules, and also communicate with the lacunae of the cementum through their fine canaliculi.

In viewing the following photomicrographs, certain phenomena of optics must be kept in mind. The thinnest sections which can be cut will present an appreciable depth as seen through the microscope. It therefore, is often necessary in the study of these processes, to follow them by focussing progressively through different planes in order to trace them. A photomicrograph showing this particular type of passage will reveal sharply only those structures appearing in the plane for which it is focussed. Adjacent portions of the same structure occurring in other planes will be revealed vaguely or not at all. Many fine passages, because of their direction, are cut transversely and appear under the microscope as fine dots.

The writer in preparing the following photomicrographs has endeavored, as far as possible, to show passages occurring in one plane. It will be readily understood that the passages here shown constitute but an extremely small proportion of these important structures.

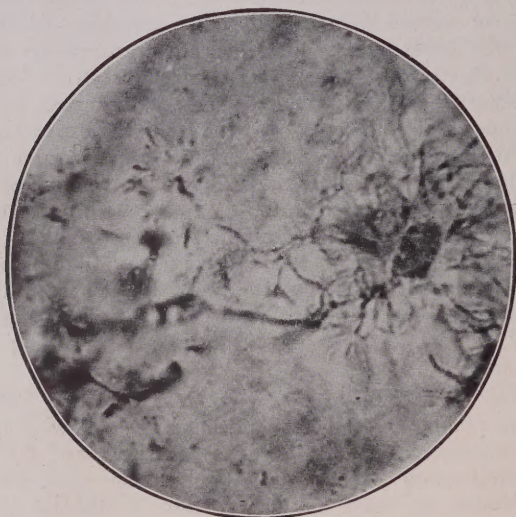


Fig. 23.—A dentinal-cemental passage. This figure proves that communication between the dentine and the cementum does exist. On the left of the figure may be seen a spindle-shaped enlargement of a dentinal tubule, from which a fine process extends to join canaliculi of a cemental lacuna.

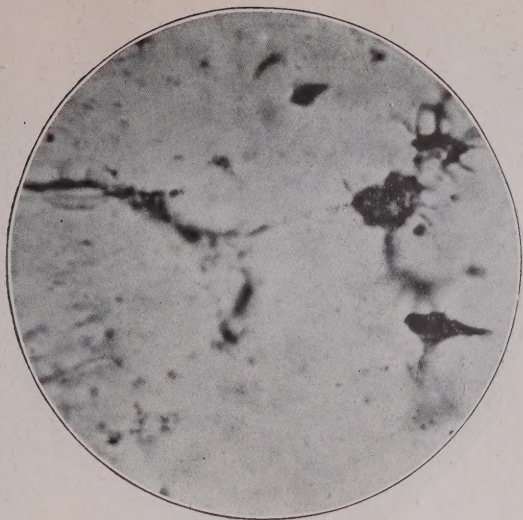


Fig. 24.—A dentinal-cemental passage. From a spindle-shaped enlargement of a dentinal tubule, on the left of the figure, a fine passage may be seen extending to a cemental lacuna.

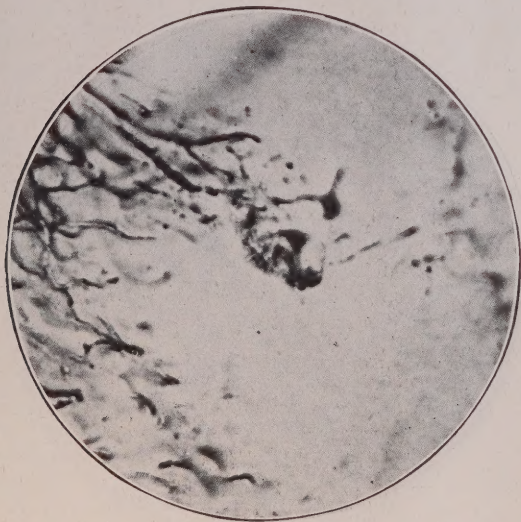


Fig. 25.—A dentinal-cemental passage. From a large pear-shaped space on the border of the dentine, on the left of the figure, a fine process extends to the cemental canaliculi.

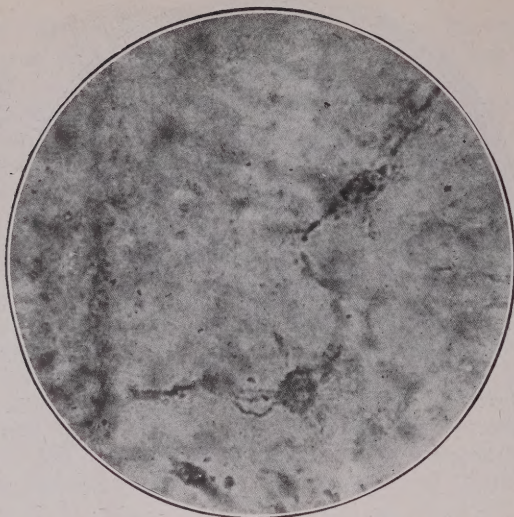


Fig. 26.—A dentinal-cemental passage. The dentine is on the left of the figure, the cementum on the right.

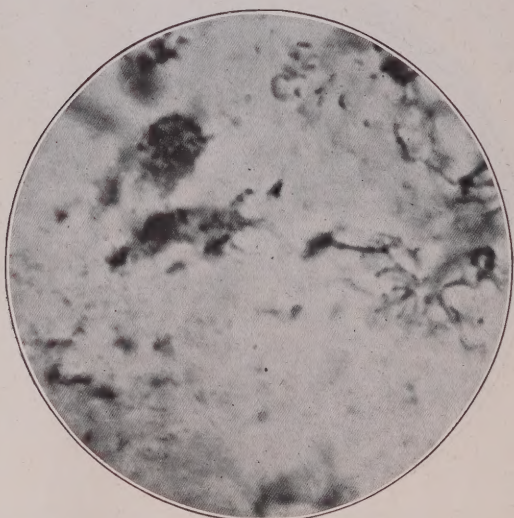


Fig. 27.—A dentinal-cemental passage. From a large irregular-shaped space in the granular layer on the border of the dentine having direct connection with the dentinal tubules, on the left of the figure, a fine process extends to a cemental lacuna.

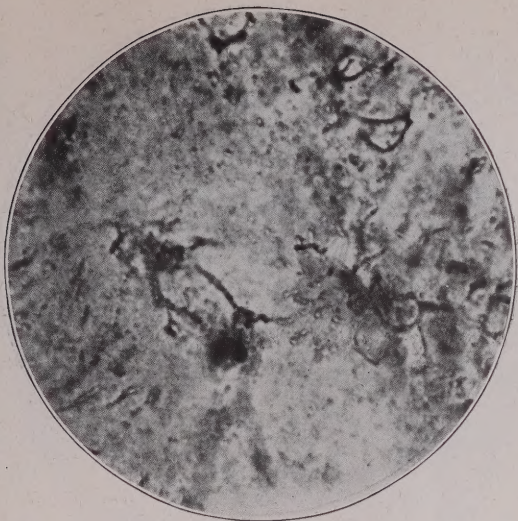


Fig. 28.—A dentinal-cemental passage. From an irregular-shaped space on the border of the dentine, on the left of the figure, a process extends to a canaliculus of a cemental lacuna.

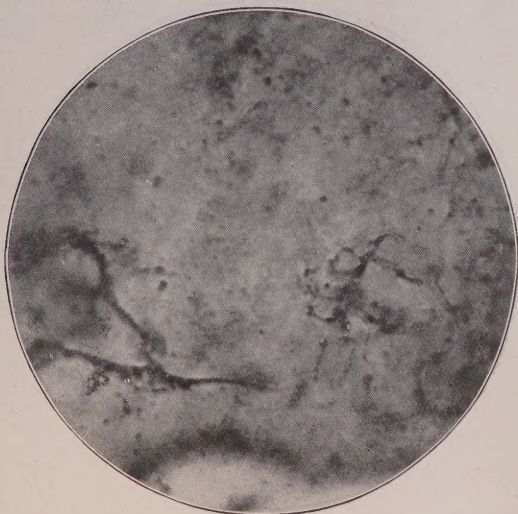


Fig. 29.—A dentinal-cemental passage. On the left of this figure, enlargements of two dentinal tubules have joined to form a small passage which extends to a cemental lacuna.



Fig. 30.—Dentinal-cemental passages. From irregular-shaped spaces on the border of the dentine, on the left of this figure, two passages are demonstrated extending to cemental lacunae. The lower passage is shown vaguely, as it is not on the same plane as the one above.

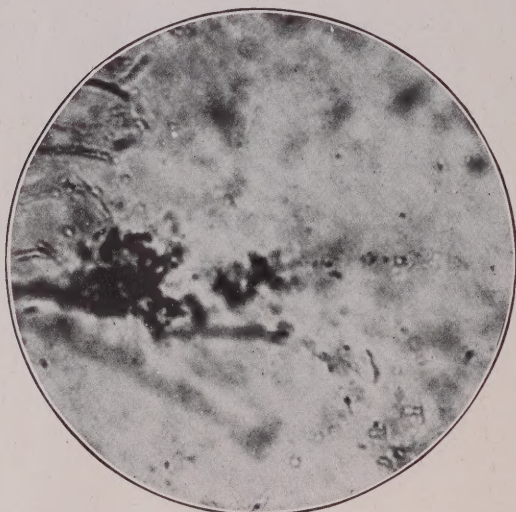


Fig. 31.—Dentinal-cemental passages. From an irregular-shaped space on the border of the denture, on the left of the figure, processes extend to cemental canaliculi. These processes, because of their direction, are cut transversely and appear as fine dots.

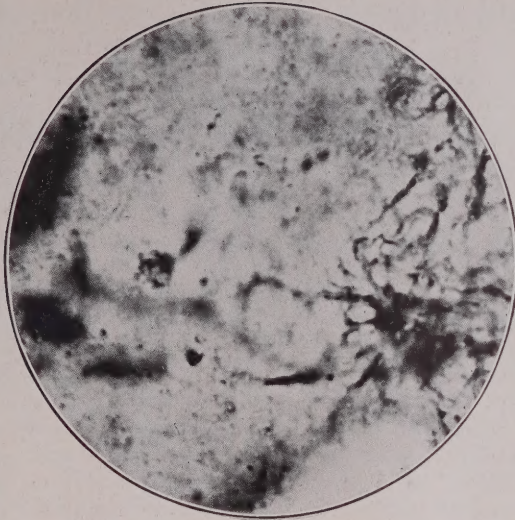


Fig. 32.—A dentinal-cemental passage. From the fusion of two dentinal tubules, on the left of this figure, a fine process extends to a canaliculus of a cemental lacuna. The dentinal tubules are not revealed sharply, as they are not on the same plane as the sharply-defined cemental lacuna.

This bulletin was read in part or in full at the following:
National Dental Association, New Orleans, Oct., 1919.
American Academy of Periodontology, New Orleans, Oct., 1919.
Montreal Dental Club, Jan., 1920.
McGill University, Montreal, Jan., 1920.
First District Dental Society, New York, March, 1920.
Columbia University, March, 1920.
Ontario Dental Society, May, 1920.
Ottawa Dental Society, March, 1922.

Histological and Histo-Pathological Studies of the Dental Pulp

HAROLD KEITH BOX, D.D.S., PH.D., F.A.A.P.

THE NORMAL CONSTITUENTS OF THE DENTAL PULP.

THE dental pulp is a delicate connective tissue of an embryonal type. "The embryonal type of connective tissue consists of a delicate protoplasmic network containing a semi-fluid intercellular substance. The network is formed by the union of the processes of irregularly branched stellate or fusiform cells whose oval nuclei are embedded in the plate-like masses of faintly granular cytoplasm. The intercellular ground substance is semi-fluid and depending on the stage of development, either structureless or traversed by indistinct fibrilli. The latter owe their origin to the cells and are produced by differentiation of the cytoplasm." (Piersol.)

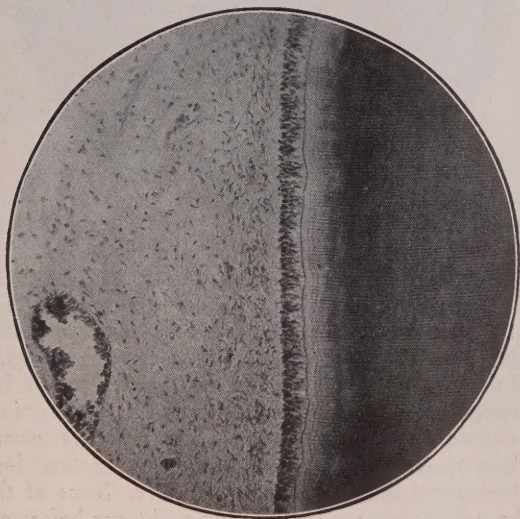


Fig. 1. Odontoblasts.

Along the periphery of the pulp is a layer of tall, columnar cells known as the odontoblasts. During the period of dentine formation, these cells are large and nucleated, and more or less columnar in shape. Some are short and thick, while others are long and thin. The nuclei are large and oval and are situated in the pulpal third of the cells. The walls of the nuclei are well defined. Extending into the dentinal tubules are long cytoplasmic processes known as the dentinal fibrils. In many instances two fibrils are given off from a single odontoblast. In some sections can be seen three or four. Delicate processes can be traced from the pulpal ends of the cells into the "basal layer of Weil," which consists of a comparatively pale and translucent zone lying between the inner ends of the cells and the pulp.



Fig. 2. Odontoblasts.

CELLS AND MATRIX.

In the root portion of the dental pulp, the cells are fusiform with the long axis parallel with the canal. In the coronal portion, the cells are round and branched cuboidal. In the large irregularly branching cells the cytoplasmic extensions are generally three or four in number, giving a stellate appearance to them. The processes given off by the cells soon taper down to mere threads which extend for a great distance throughout the intercellular substance. Some of the extensions of the stellate cells project for quite a distance before narrowing

and in many cases they sub-divide into two or more threads. The cytoplasm of the cells is faintly granular, the nuclei fairly large and ovoid in shape. In them a distinct chromatin network can be seen. Some nuclei seem to take the stain more deeply than others.

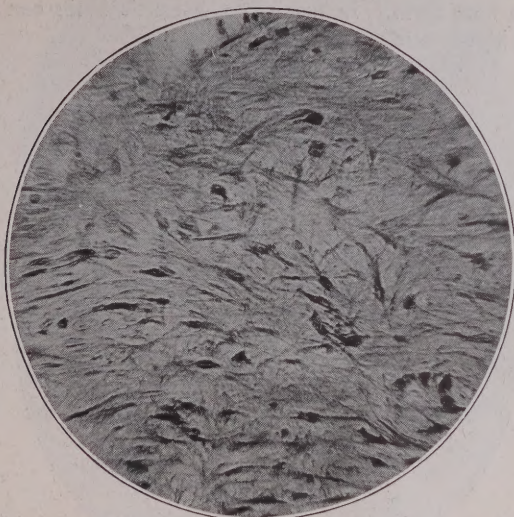


Fig. 3. Pulp cells.

Upon reviewing the researches by the most noted dental histologists, on the intercellular substance of the pulp, it is evident that very little is known concerning its structure. There are many conflicting opinions. The essayist feels that the studies shown in the following figures will give us a more definite understanding of the nature of this tissue. The fine elements in the pulp matrix are not brought into view unless special stains are employed to color them. Mallory makes the statement that connective tissue cells produce under different conditions three kinds of fibrils, fibroglia, collagen and elastic. In mucous connective tissue, mucus composed of a group of nitrogenous, albuminous substances called mucins, occurs between the collagen fibrils.

The fibroglia fibrils have an intimate relationship to the cytoplasm of the cell. They are very delicate, forming part of the periphery of the cell from which they arise and run along its cytoplasmic processes.

Collagen fibrils run in wavy bundles made up of delicate fibrils, cemented together.

The elastic fibrils occur in the form of a network of fibrils varying in size, and are found only in certain situations as in the walls of the blood-vessels.

In figures numbered 4 and 5, special preparations and studies can be seen. It will be observed that there is very little unoccupied space. In the sections from which the photomicrographs were made the collagen fibrils are shown as reddish-brown wavy bundles, the fibroglia as blue fibrils. In figure No. 5 elastic fibrils can be seen around the blood vessels.

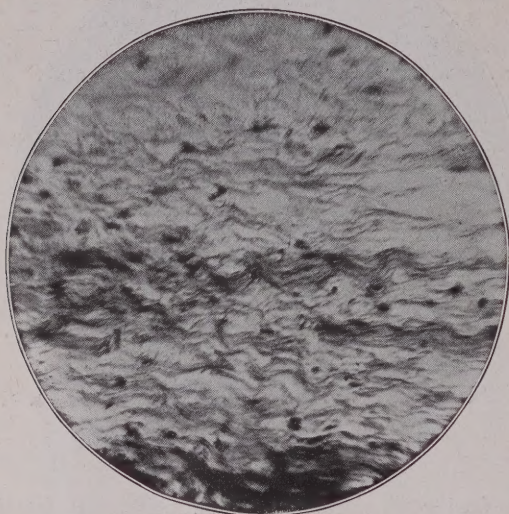


Fig. 4. Collagen fibrils in pulp.

It must not be overlooked that besides the fibrils mentioned, there are also in great abundance throughout the matrix, the hair-like processes of the cells.

As a point of interest, it might be stated that Raphael Isaacs, of the Anatomical Laboratory of the University of Cincinnati, in observations on connective tissue and neuroglial fibrillae, believes, after a study of living connective tissue in cover glass and hanging drop preparations, that the intercellular substance is homogeneous.

The connective tissue fibrillae described as exoplasmic fibrillae by Mall and others do not appear in the living intercellular connective tissue colloid. They can be produced in fresh tissue under the microscope through any agency which will cause the material distributed in the intercellular substance, to shrink up. The pattern and delicacy varies with different fixatives. He also believes the spindle-shaped type of connective tissue cell to be the most stable form, the stellate cells often reverting to this shape when freed from surrounding pressures.

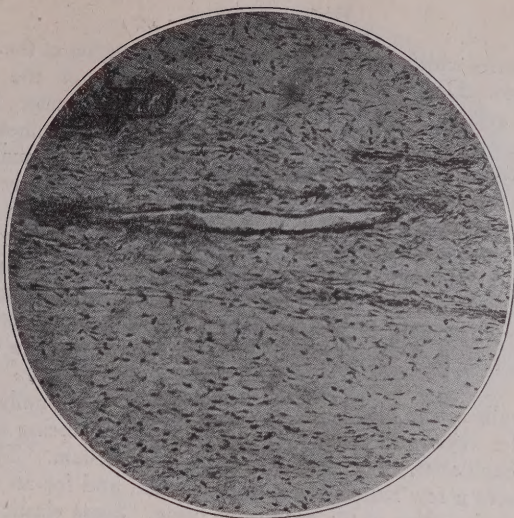


Fig. 5. Elastic fibrils in pulp.

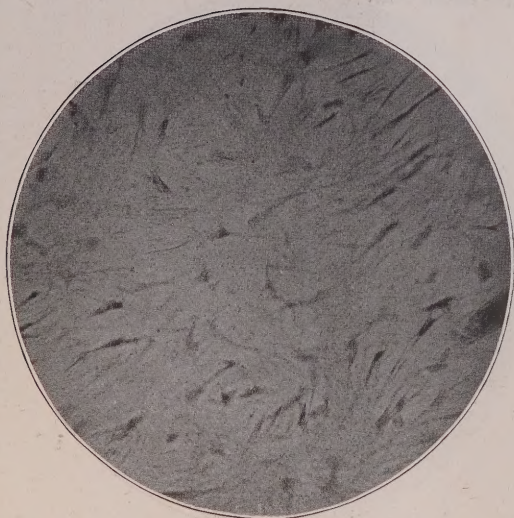


Fig. 6. Processes of pulp cells.

BLOOD SUPPLY.

The arteries which vascularize the pulp are branches of the Superior and Inferior Dental and Infra-orbital divisions of the Internal maxillary artery. Usually three or four branches enter the pulp through a minute canal in the apex of the root. Sometimes we find two or three canals instead of one. In many cases, usually adult teeth, there is but one artery nourishing the pulp. Shortly after its entrance, each artery passing occlusally, repeatedly gives off branches which become smaller in calibre as the surface of the pulp is approached. Beneath the odontoblasts, a rich capillary plexus is formed. Small veins following the course of the arterioles collect the blood, and becoming larger in calibre, following the course of the larger arteries, they proceed to the apical foramen where they pass out.

The walls of the blood-vessels of the pulp are unusually delicate, the smaller veins and sometimes fairly large ones being composed, like the capillaries, of a single layer of endothelium. The larger arteries have a few muscle fibres in the media, and for an adventitia a slight condensation of the connective tissue. Some elastic fibres are found in the walls of the large arteries.

The endothelial cells do not produce any intercellular substance unless it be cement substance. They are more or less flattened, the oval nuclei centrally located and taking the stain less deeply than the connective tissue cells.

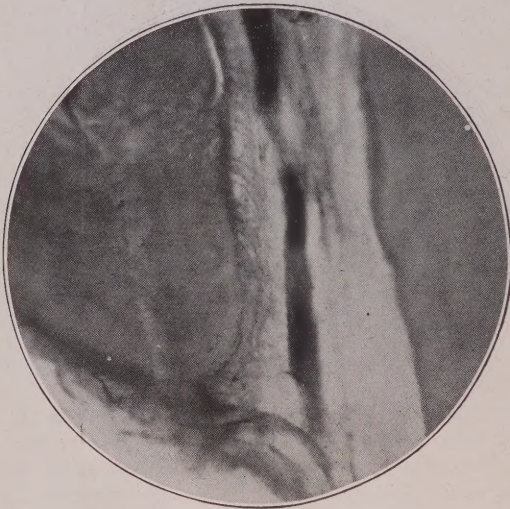


Fig. 7. Blood-vessel entering apical foramen.



Fig. 8. Artery and vein in pulp.

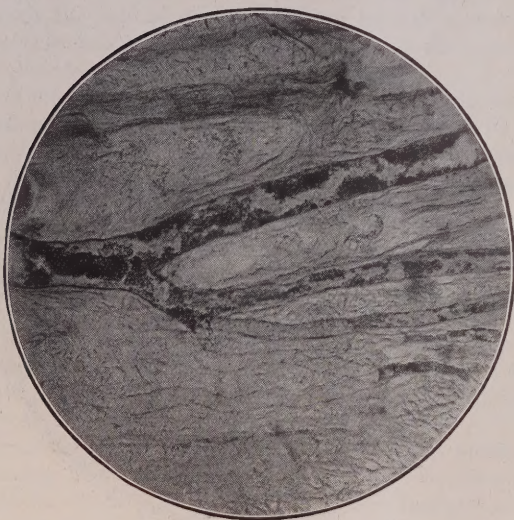


Fig. 9. Pulpal artery and its branches, which become smaller in calibre as the surface of the pulp is approached.

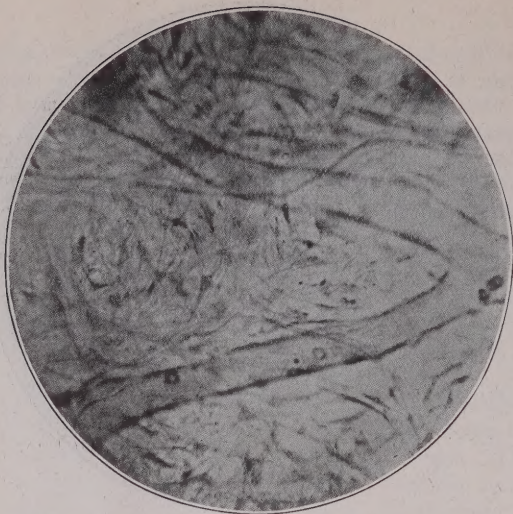


Fig. 10. A large blood-vessel in the pulp, the walls of which are composed of a single layer of endothelium.

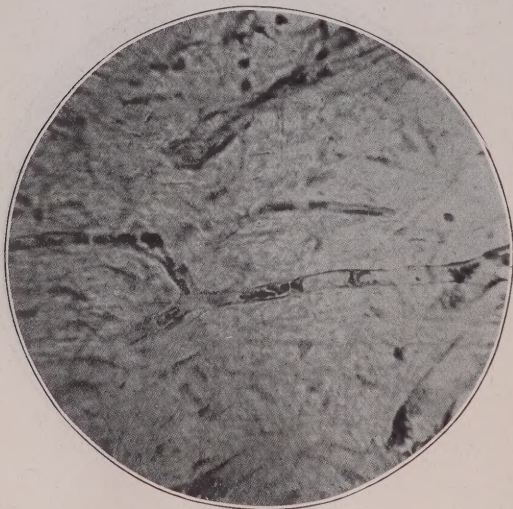


Fig. 11. Capillaries on the periphery of the pulp.

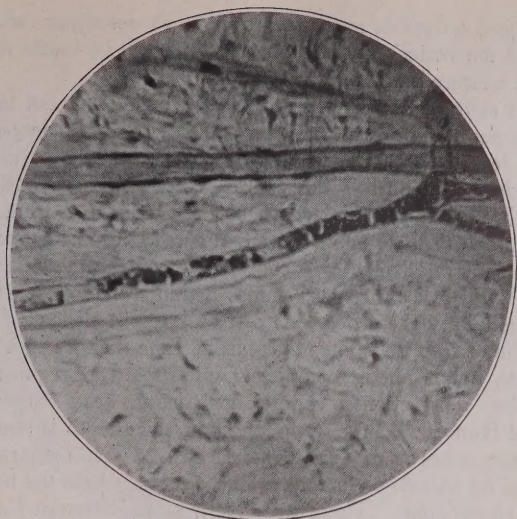


Fig. 12. Capillaries on the periphery of the pulp.

THE NERVOUS SYSTEM.

This subject above all others in dental histology has held the foremost place in the field of earnest endeavor for half a century. The study is a fascinating one and also of first importance, especially in relation to the innervation of the dentine.

Three or more nerve trunks, in company with the arteries, enter the apical foramen and pass into the pulp in the direction of its long axis. These trunks contain the medullated nerve fibres. In nearly every case, the main trunks follow a course parallel to the large arteries and in their distribution seem to follow the arterioles. As the periphery of the pulp is approached, the branches consist, in many cases, of two or three nerve fibres running parallel. In the subodontoblast region, the medullary sheaths are lost, and as beaded fibres, the nerve filaments enter into an intricate plexus from which they pass between and around the odontoblasts. Many pass to the dentinal ends of the odontoblasts, some uniting with others to form a delicate plexus, but others pass into the tubules and can be traced for a short distance.

No subject in dental histology has attracted the attention of a greater number of investigators than the study of the termination of the neurofibrils which pass from the plexus of Raschow in the subodontoblast region of the pulp toward the dentine. From a purely histological standpoint, it has proved to be one of great fascination,

and has been a topic of much controversy. A description and demonstration of the writer's findings on this topic will be made the subject matter of a future bulletin.

Several methods have been employed which bring out in different ways the nerve supply of the pulp, and in order to interpret them easily, a few lines on the structure of nerve fibres is of importance. The fundamental part is the central cord or axis cylinder. This extends through the whole length of the nerve fibre from its origin in the neurone to its terminal arborization. The axis-cylinder is surrounded by a relatively thick coat known as the medullary sheath, outside of which lies the neurilemma, a thin structureless envelope.

The medullary sheath consists of two parts, a delicate framework and myelin, a fatty substance that fills it. The sheath is not uniformly continuous, but is almost completely interrupted at regular intervals marked by constrictions. These constrictions are known as the "nodes of Ranvier." In a fresh condition, this sheath is homogeneous but changes soon occur and segments can be seen, separated from each other by narrow clefts that extend obliquely from the neurilemma to the axis-cylinder. These are known as Schmidt-Lantermann segments.

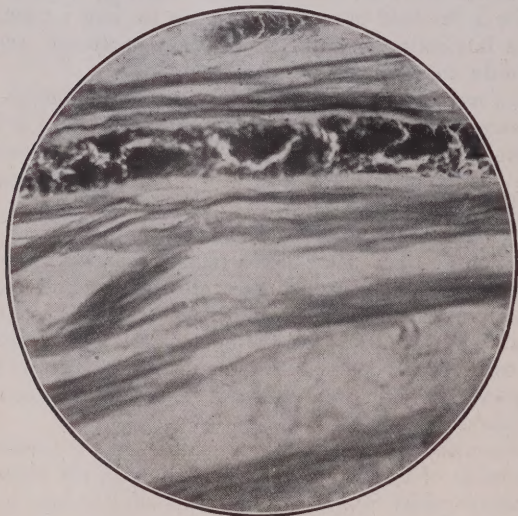


Fig. 13. The medullary sheaths of pulpal nerves.

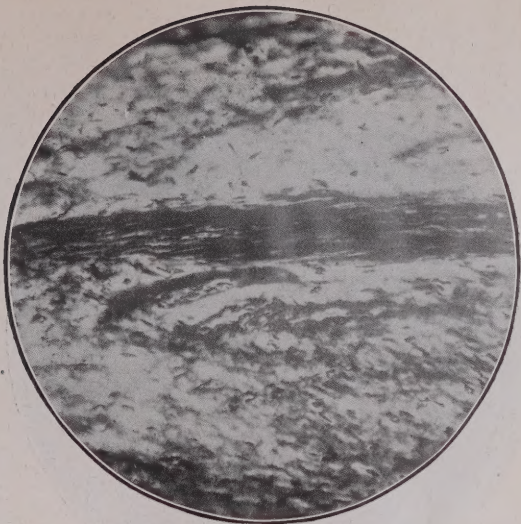


Fig. 14. The medullary sheaths of pulpal nerves.

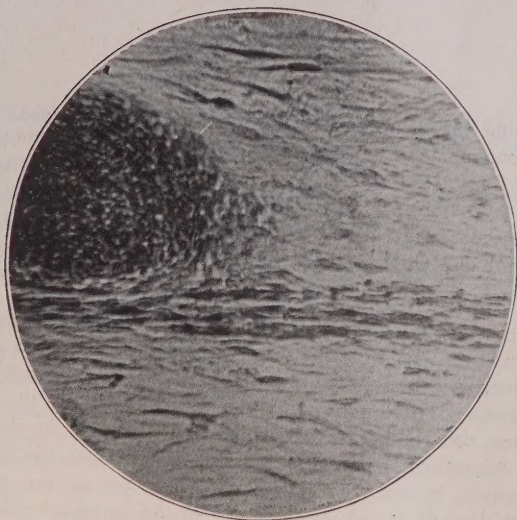


Fig. 15. Axis-cylinders of nerves in the pulp.

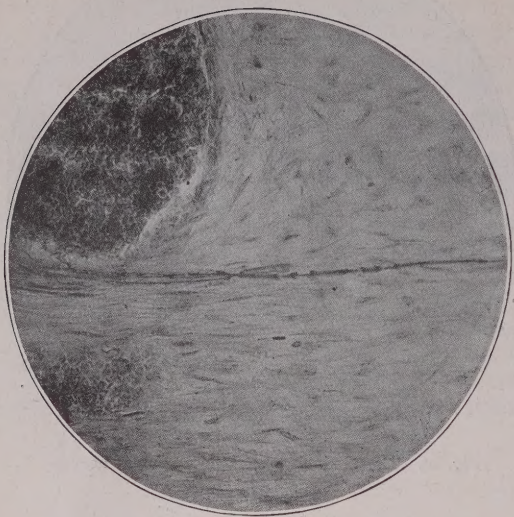


Fig. 16. Axis-cylinders of nerves in the pulp.

Concerning the neurofibrillar arborizations which appear as delicate filaments minutely beaded, Schafer's explanation, which is accepted by most authorities, is: "That the fibrils are not solid, but of a semi-fluid nature is probable from the fact that they easily become varicose with little beadlets or droplets upon their course. This is what one would expect with a viscous fluid but not with a solid."

While the nerves of the pulp consist chiefly of medullated fibres, the sensory fibres which convey sensation from the tissues to the brain, others, which are non-medullated, are frequently observed accompanying them. These non-medullated fibres constitute the neuraxes of neurones, the cell-bodies of which are situated in sympathetic ganglia. According to Bohm, Davidoff and Huber, the ganglia of the sympathetic nervous system "comprise those of the two great ganglionated cords found on each side of the vertebral column, and extending from its cephalic to its caudal end, with which may be

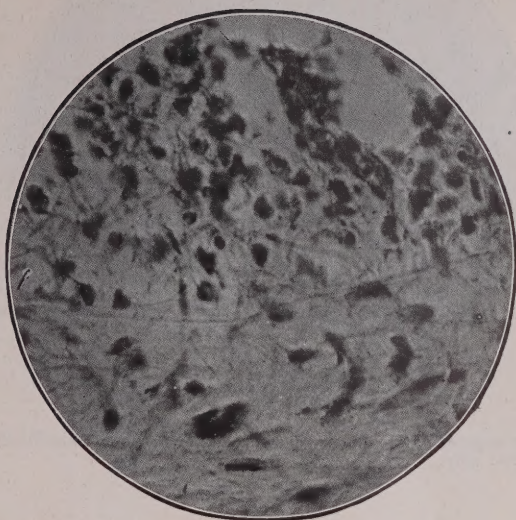


Fig. 17. Neuro fibrillar arborizations beneath the odontoblasts.

grouped certain cranial ganglia having the same structure, namely, the sphenopalatine, otic, ciliary, sublingual and submaxillary ganglia; also three unpaired aggregations of ganglia found in front of the spinal column of which the cardiac is in the thorax, the semilunar in the abdomen, and the hypogastric in the pelvis; and further, large numbers of smaller ganglia, the greater number of which are of microscopic size and are found in the walls of the intestinal canal and bladder, in the respiratory passages, in the heart, and in or near the majority of the glands of the body."

These non-medullated fibres in the dental pulp branch repeatedly, and at their terminations, naked varicosed axis-cylinders end in the form of clusters of granules on the blood-vessels. Some of the small lateral twigs terminate in one or two small granules.

From a careful examination of text-books and current literature, the essayist is of the opinion that these endings of the neuraxes of sympathetic neurones have never been previously observed in the dental pulp.

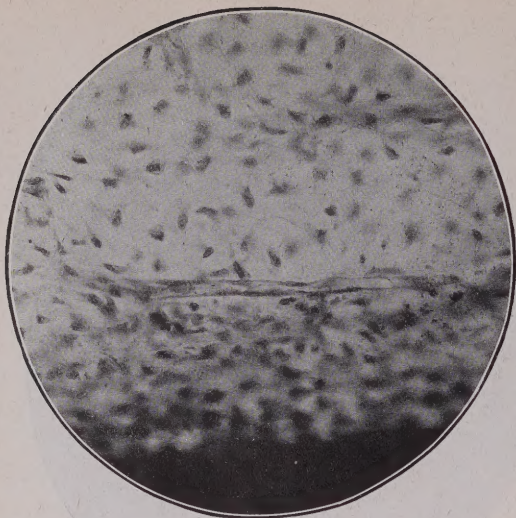


Fig. 18. Endings of axis-cylinder of sympathetic neurone on a blood-vessel in the dental pulp.

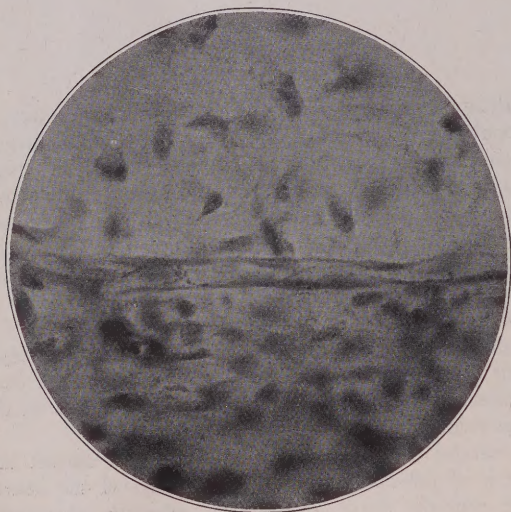


Fig. 19. Neuraxes of sympathetic neurones on pulpal blood-vessel.

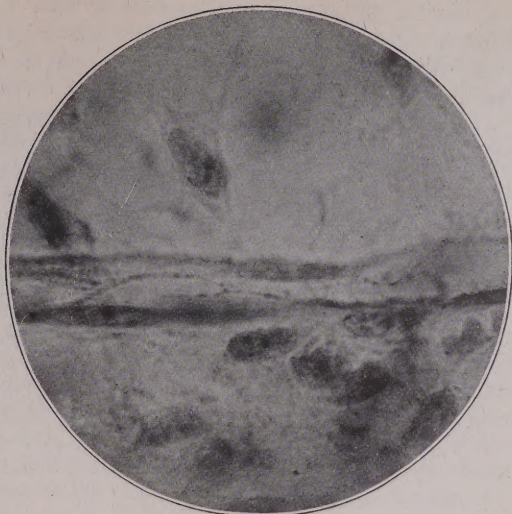


Fig. 20. Neuraxes of sympathetic neurones on pulpal blood-vessel.



Fig. 21. Cluster of granules on pulpal blood-vessel, the termination of an axis-cylinder of sympathetic neurone.

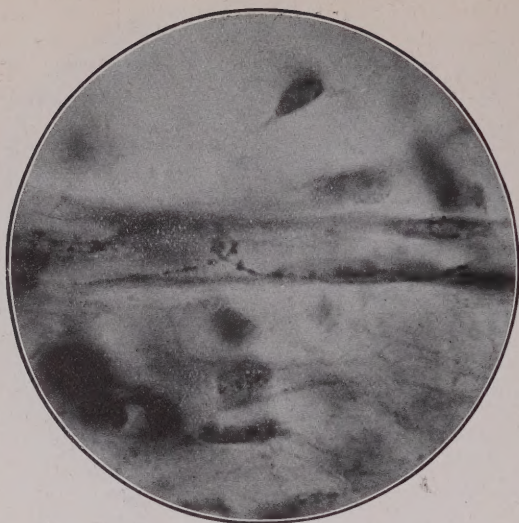


Fig. 22. Cluster of granules on pulpal blood-vessel, the termination of an axis-cylinder of sympathetic neurone.

PATHOLOGY OF THE DENTAL PULP.

The pulp being a very soft tissue in intimate relation with, and enclosed in a hard covering of dentine, presents to the student of pulpal pathology, many obstacles in the process of fixation and sectioning. The difficulty of perfecting a technique by which the tissue can be examined microscopically, with a minimum of change brought about in the process, and the fact that the normal structure is not thoroughly understood, accounts in part for much of the obscurity surrounding the true pathological changes in the dental pulp. By keeping in mind the following peculiar characteristics of this organ, as a background from which to view these morbid changes, the essayist feels that the modifications of general principles manifested in this tissue will be better appreciated.

(1) The inexistence of collateral circulation in the dental pulp causes it to pass quickly from certain hyperemic conditions to infarction and necrosis.

(2) The pulp is incased in a hard, unyielding tissue, the dentine, and in hyperemic disturbances, this prevents swelling and restricts the exudation of serum.

(3) The great vascularity of the dental pulp, the delicate structure of the walls of the blood-vessels, and the semi-fluid nature of the matrix, render this tissue susceptible to circulatory changes.

(4) A state of balance is present in the normal pulp, with an abundant vascular supply on the one hand and a protective covering of tissue on the other. Loss of this tissue, so often the case as in caries, abrasion or erosion, creates a new condition, subjecting the pulp to increased irritations.

(5) The fact that there is but one outlet for the veins increases the danger of strangulation.

(6) Owing to the close relationship between the blood supply of the pulp and the pericementum, disturbances in the pericemental circulation are frequently manifested in the pulp. The periapical pericementum receives blood-vessels from the medullary spaces of the bone, some of which, on subdivision pass through the apical foramen into the pulp. In the majority of cases of traumatic occlusion, the periapical tissues are subjected to a force of unnatural magnitude. The dental pulp, then, is peculiar in that its blood supply passes through a region subject to circulatory disturbances of traumatic origin. These, in turn, are often manifested in the pulp. It is the opinion of the writer that many necrotic pulps of an otherwise obscure etiology, and certain of the degenerations of the pulp, because of nutritional interference, can be accounted for in this way.

(7) The pulp on account of its delicate structure is peculiarly subject to degenerations.

LESIONS PRODUCED BY SPECIAL INJURIOUS AGENTS.

(1) *Sudden changes of temperature.*

Extremes of heat or cold produce alterations in the circulation of the pulp. Loss of normal covering of the pulp renders it susceptible to lesser extremes. Frequent sources are hot and cold foods, the polishing of fillings, and the injudicious or unscientific grinding of enamel.

Reaction.

The writer is inclined to hold that the "physiological" hyperemia in mild thermal changes is largely a capillary one. The periphery of the pulp is supplied by a rich capillary plexus and is affected first in stimuli from without. The hyperemia is brought about by a stimulation of the vasodilators (neurotonic). When these stimuli are repeated in excess, a "pathological" hyperemia is produced, by the paralysis of the vasocontractors (neuroparalytic). The onflow of blood through the capillaries is hindered, more blood is poured into the arteries, with the result that they become congested.

A direct arterial hyperemia is often the result of sudden thermal extremes. The arteries are expanded and varicosed, the plasma zone is lost, and the vessels are filled with masses of densely packed red and white blood-cells. Areas can be seen in which the red cells have escaped into the surrounding tissues. The veins are collapsed, circulation cannot be restored and the pulp dies.

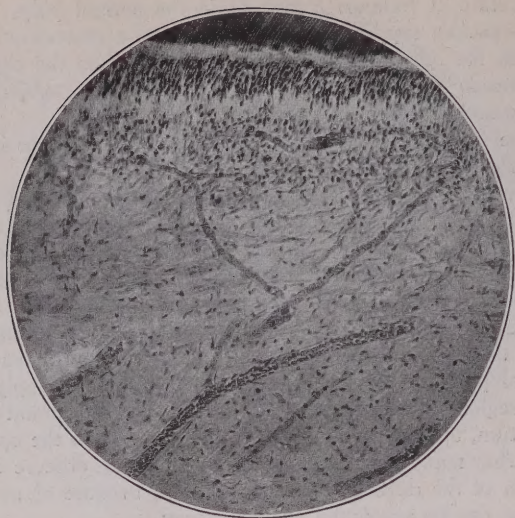


Fig. 23. Capillary hyperemia of pulp.

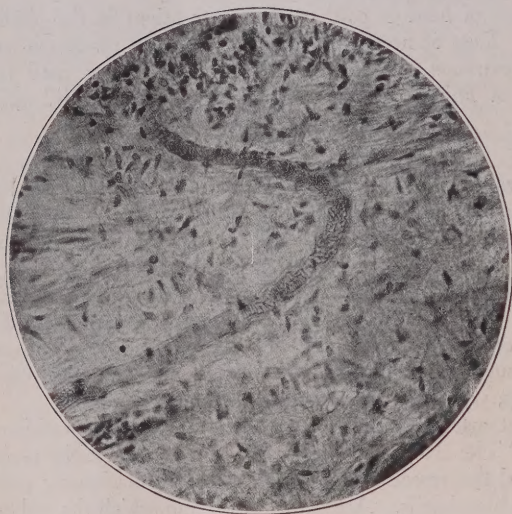


Fig. 24. Capillary hyperemia of pulp.

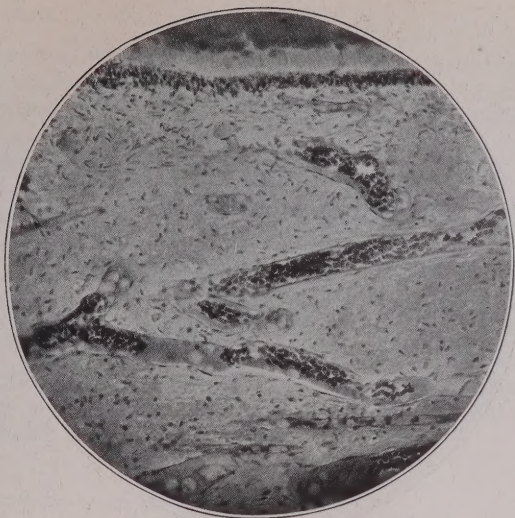


Fig. 25. Pathological hyperemia of pulp.

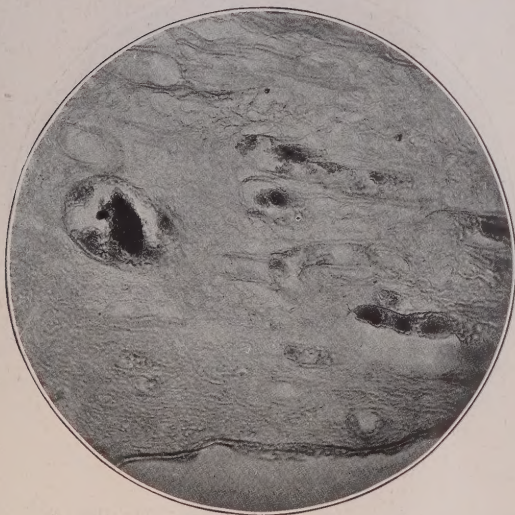


Fig. 26. Pathological hyperemia of pulp.

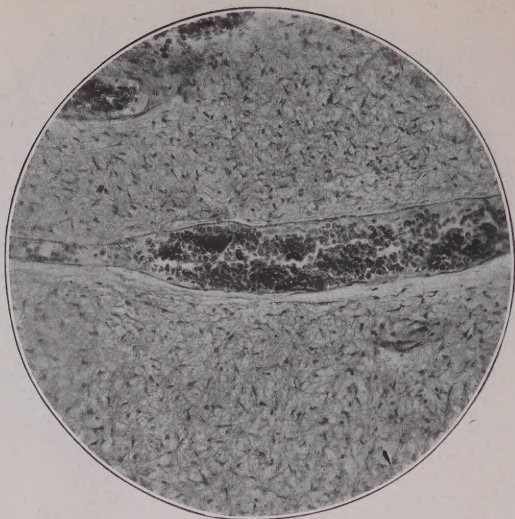


Fig. 27. Pathological hyperemia of the pulp. Note the enormous dilatation of the blood-vessel on part of its course.



Fig. 28. Pathological hyperemia of the pulp. Note that most of the red blood-cells are grouped in rouleaux.

(2) *A Blow.*

The arteries which nourish the pulp and pericementum have a common origin. The same is true of the nerves. An injury to the pericementum from a blow on the tooth, is often manifested in the pulp as a direct arterial hyperemia. If the blow has been severe, the capillary anastomoses at the periphery of the pulp are not adequate to carry on the circulation, a pathological hyperemia results, followed by death of the organ through infarction. Greenfield of Edinburgh has demonstrated that within five hours after an obstruction, an infarct is always intensely congested and reddish-purple. Later, when necrotic changes have taken place, the part becomes paler and of a pinkish color. The condition known as "coagulation necrosis" takes place at this stage. The cells undergo the changes peculiar to necrotic cells, finally becoming homogeneous. Cells, capillaries and their contents become more or less fused with each other, forming a structureless mass.

(3) *Traumatic Occlusion.*

In every case of traumatic occlusion, undue pressure is exerted in the direction of the long axis of the tooth. The entire pericementum is subjected to an abnormal strain, and invariably there is produced a



Fig. 29. Arterial hyperemia of pulp.

circulatory disturbance, varying in degree, throughout this tissue. Certain types of traumatic occlusions tend to produce an excessive condensation of the periapical pericementum. Dependent upon the intensity of this condensation, the blood-vessels are more or less constricted and the flow of blood through them is partly cut off. When the pressure is removed, there is a consequent dilatation of the blood-vessels. Owing to the close relationship between the blood supply of the pericementum and the pulp, this disturbance is frequently manifested in the pulp as an arterial hyperemia.

(4) *Bacteria.*

Exposure to carious dentine is the greatest source of infection to the dental pulp. Other common causes are accidental exposure and contact with the saliva through fracture in the dentine and from the general circulation.

In caries, bacteria gain entrance into the pulp shortly after the dentine in contact with it becomes softened. The different stages by which bacteria penetrate the dentine and finally reach the pulp, are seen in Figures Nos. 30, 31, 32, 33, 34, 35, 36.

When the acid produced by bacteria on the surface of the enamel has dissolved out the cement substance between the enamel rods and has filtered down through the spaces formed, to the amelo-dentinal junction, decalcification of the dentine soon follows. Shortly after the enamel rods begin to fall out bacteria find entrance into the fine tubules at the periphery of the dentine.

The dentine is continually decalcified in advance of the growing micro-organisms which easily pass along the tubules. Due to the action of enzymes produced by the bacteria, the organic matrix is changed and the infected tubules become enlarged. In many instances the enlargement is regular along the whole course of the tubules, while others are characterized by the presence of oval swellings situated here and there upon the tubules. The former have been called "pipe-stem" tubules, and the latter "liquefaction foci."

These foci are crowded with bacteria and many of them fuse together to produce cavities which ultimately destroy the dentine.

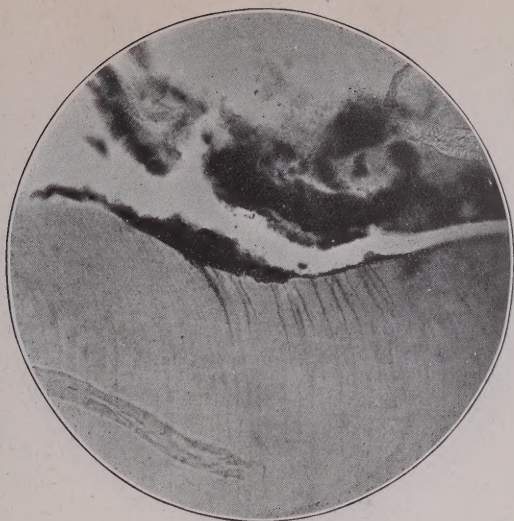


Fig. 30. Bacterial plaque and early stage of tubule infection.

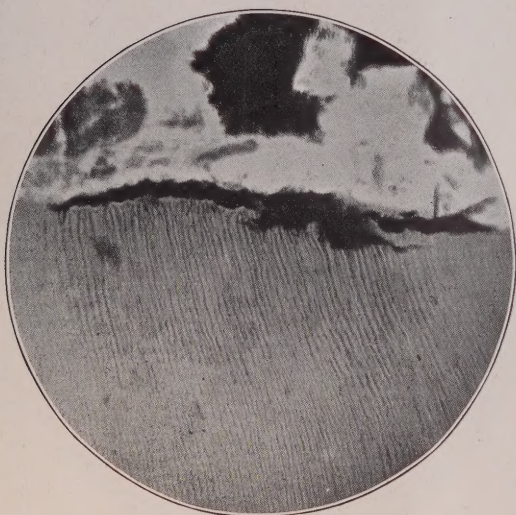


Fig. 31. Bacterial plaque and more extensive tubule infection.

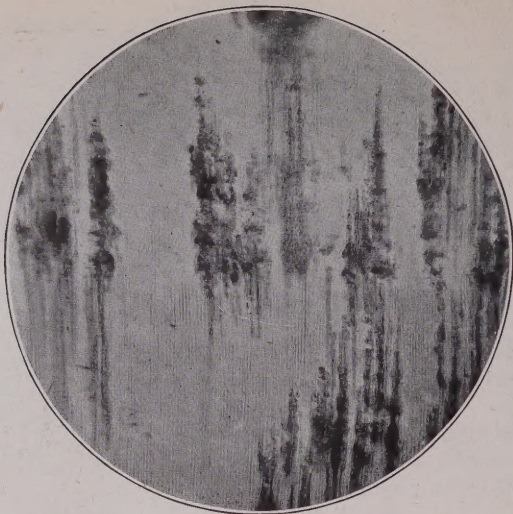


Fig. 32. "Pipe-stem" tubules and small "liquefaction foci."

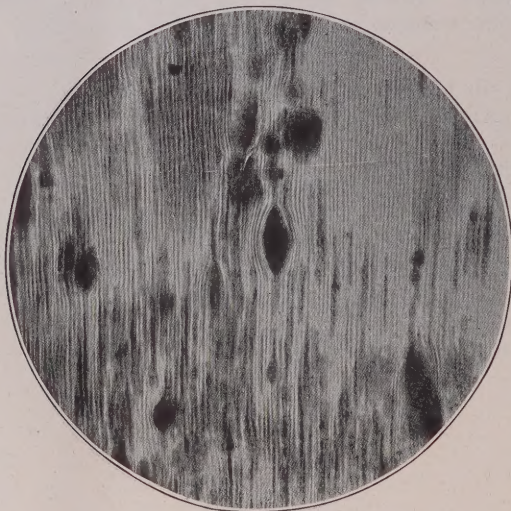


Fig. 33. Larger "liquefaction foci" in caries of dentine.

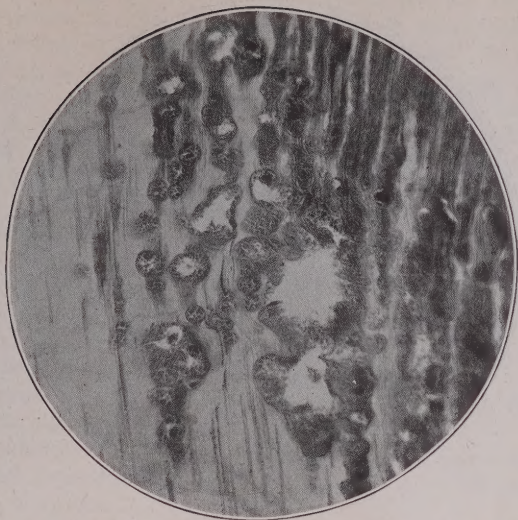


Fig. 34. Fusion of "liquefaction foci."

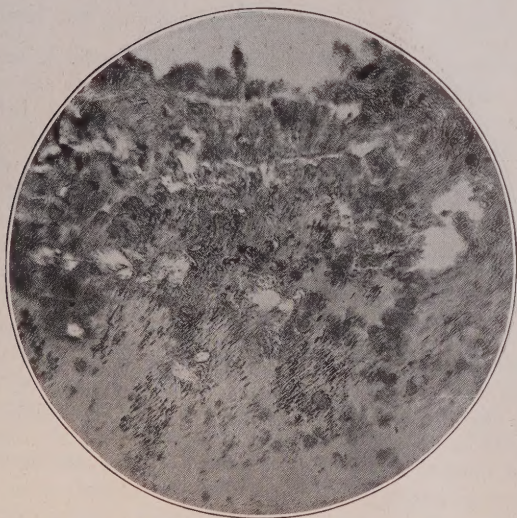


Fig. 35. Extensive caries of dentine.

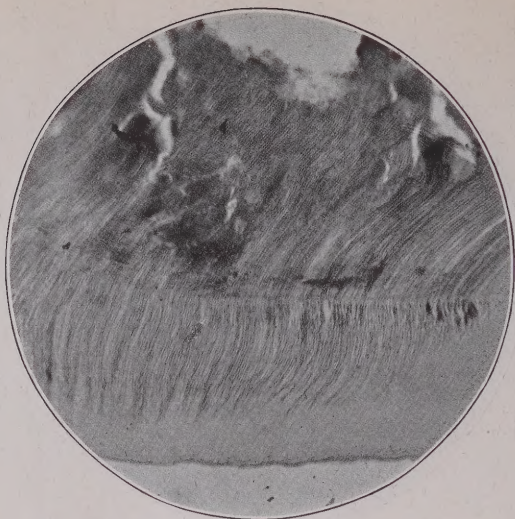


Fig. 36. Late stages in caries of dentine (cavity formation).

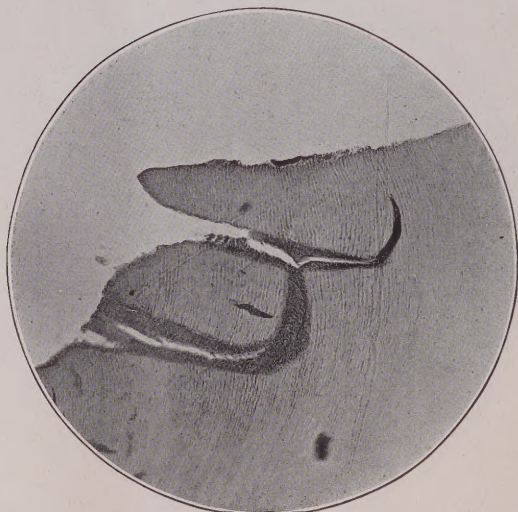


Fig. 37. Masses of dentine undermined by bacterial invasion.

As was stated before, bacteria find entrance into the pulp shortly after the dentine in contact with it has been decalcified. The softened dentine is filled with micro-organisms and the pulp is practically exposed to the saliva. These micro-organisms, including pyogenic ones, make their way through the odontogenetic zone, passing between the odontoblasts into the "basal layer of Weil," where they usually spread laterally. The toxins and injury done to the tissue cells soon induce an abundant emigration of polymorphonuclear leukocytes. In addition, fibroblasts and vascular endothelium proliferate abundantly to replace cells of their own type which have been destroyed. Necrosis, occurring quickly for a definite area surrounding the bacteria, is the characteristic injury produced by the toxin of the staphylococcus pyogenes aureus. Through the action of the ferments secreted by the polymorphonuclear leukocytes, the necrotic tissue is digested and softened, so that abscess formation occurs.

In the writer's sections on infections of the dental pulp, the areas of leukocytic infiltrations seems to fall into three groups:

- (a) The infiltration is regional and superficial. Upon removal of the softened tissue and exposure to the saliva, it is followed by a progressive ulceration.
- (b) The infiltration is regional, often multiple, and deep within the substance of the pulp, followed by liquefaction and pus production, and death of the pulp.
- (c) The infiltration is diffuse, with a predominance of plasma cells.

(a) *Regional and superficial infiltrations.*

Examples of type of reaction in the dental pulp, from the earliest stage when the overlying infected dentine is still in contact with this tissue, to the later stages where there is manifested a great loss of pulp tissue through ulceration, are shown in Figures 38, 39, 40, 41, 42, 43. In Figure 38, an infiltration of leukocytes has taken place on the surface of the pulp, although actual contact with the saliva has not been established. In Figure 39, the softened dentine has been so removed that the pulp is subjected to the fluids of the mouth. On the surface, the tissue is breaking down. A line of demarcation can be seen between the necrotic area and the regenerating fibroblasts and budding capillaries. The ulceration is progressively destroying the pulp. In figure 40, the entire pulp is infiltrated with leukocytes and loss of tissue is taking place superficially. The whole pulp is in a state of degeneration. The blood vessels are choked with red and white blood-cells. In figure 41, can be seen a typical example of gradual destruction of the pulp by ulceration. The pulp has been lost in the pulp chamber and the suppurative process is proceeding into the root-canals. Fibroblasts are attempting to wall off the

condition. In Figure 42, a fine example of ulceration of the pulp is shown. In the section from which this was taken, abscesses are present in the deeper portions. At the pulpal edge of the ulcer, fibroblasts are proliferating in great abundance. Budding capillaries in great numbers are extending from all directions toward the surface attempting to fill the area with frame-work of new vessels. On the surface there is an exudate made up of fibrin, dead leukocytes and bacteria.

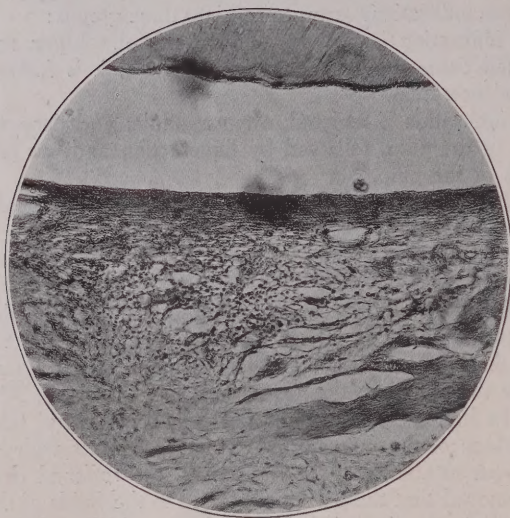


Fig. 38. Ulceration of the pulp. Small leukocytic infiltration near the surface.



Fig. 39. Ulceration of the pulp, later stage.

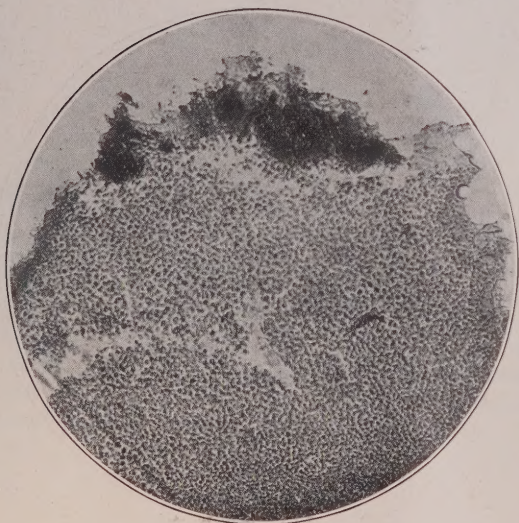


Fig. 40. Ulceration of the pulp, later stage.



Fig. 41. Ulceration of the pulp, later stage.



Fig. 42. Pulpal ulceration.

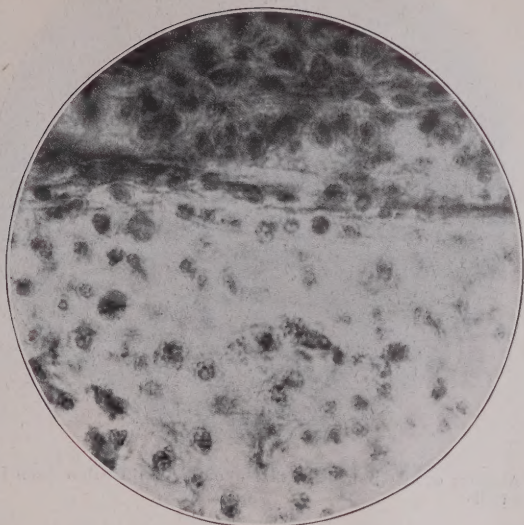


Fig. 43. Pulpal ulceration. High magnification near ulcer edge.

(b) *Regional and deep infiltrations.*

Figures 44, 45, 46, 47, 48, are examples of different stages of this type, from a very minute accumulation of leukocytes to the formation of definite abscesses deep in the tissue of the pulp. In Figure 44, can be seen a very early stage where the infiltration of cells is very small. Figures 47 and 48, show abscesses in the interior of the pulp, where considerable extension of tissue solution has taken place. Fibroblasts and capillaries proliferated for repair are being included in the extension of the destructive process.



Fig. 44. Abscess of the pulp. Small leukocytic infiltration deep in the tissue of the pulp.

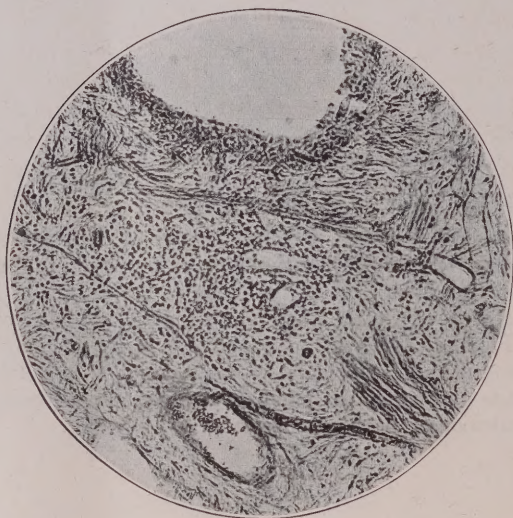


Fig. 45. Abscess of the pulp, later stage.

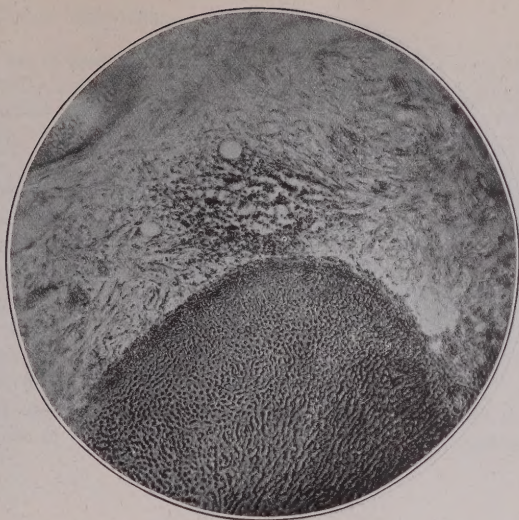


Fig. 46. Abscess of the pulp, later stage.

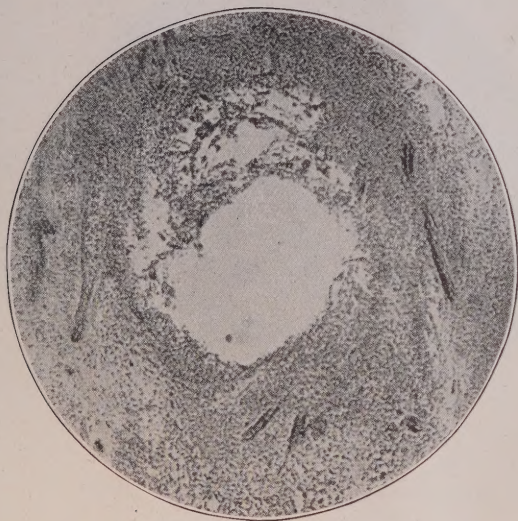


Fig. 47. Abscess of the pulp. Note the great extension of tissue solution.

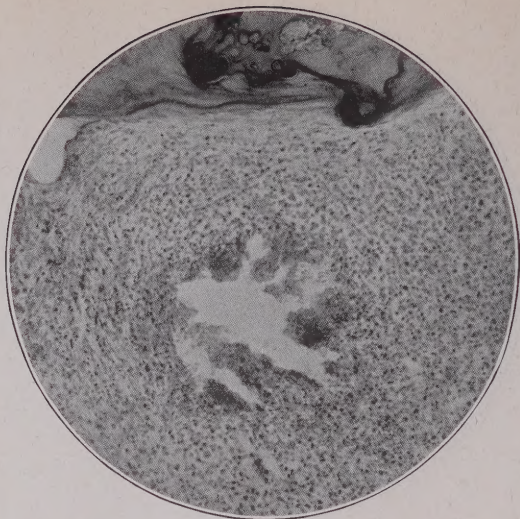


Fig. 48. Abscess of the pulp.

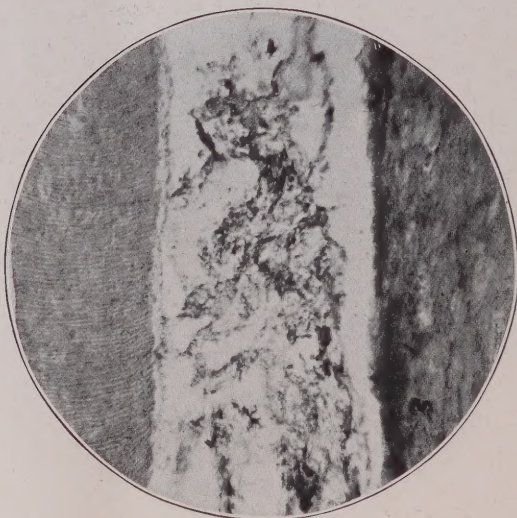


Fig. 49. Necrotic pulp.

(c) *Diffuse infiltration.*

In an examination of a number of infected pulps, the writer has frequently noticed a type of diffuse infiltration where no sign of tissue destruction can be observed. Plasma cells seem to be the conspicuous feature. Some observers believe that these cells do not play any part in the development of fibroblasts and that they are derived from lymphocytes. Maximow, a noted pathologist, holds the view that these cells originate either from lymphocytes or connective tissue cells and may develop into fibroblasts.

Figures 50 and 51, show examples of this type in which the greater bulk of the pulp tissue is filled with plasma cells. Extending through them in all directions, are newly formed capillaries. The writer believes that in these cases, the inflammatory reaction has extended over a considerable length of time and that the infective agents are of a mild character. The evident conclusion from these studies is, that infections of the dental pulp practically always terminate in its death.

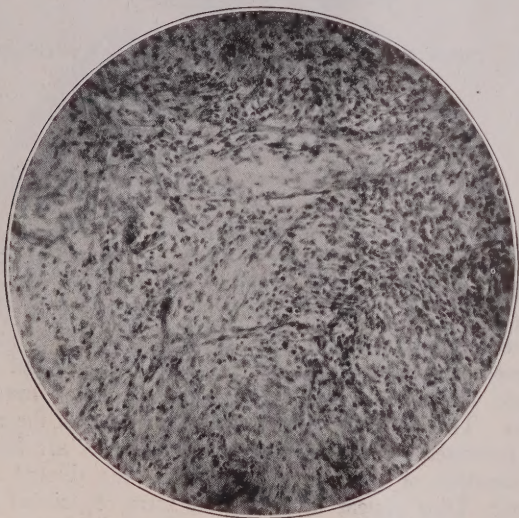


Fig. 50. Diffuse infiltration of the dental pulp.

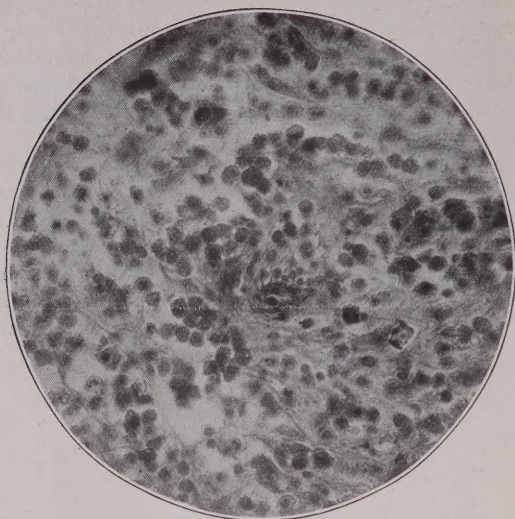


Fig. 51. Diffuse infiltration of the dental pulp. High magnification.

Repair.

Lesions involving destruction of tissue as in necrosis or abscess formation, tend to heal by granulation tissue. This term is applied to young tissue composed of fibroblasts and vascular endothelium which are reproducing to replace destroyed connective tissue and blood-vessels. The fibroblasts appear as flat elongated cells with large pale vesicular nuclei containing a delicate framework of chromatin. The cytoplasm extends from each end of the cell as one or more processes. Hand-in-hand, new capillaries are formed from the proliferation of the endothelium lining the dilated superficial capillaries. They appear at first in the form of pointed buds consisting of spindle-cells with cytoplasmic processes which are sent out first. The individual buds tend to grow towards one another and form narrow columns which unite laterally to construct a ramifying vascular net-work. Finally many of these newly formed capillaries

disappear, while only the largest ones persist in the fully formed scar tissues. The essential part of granulation tissue is fibroblasts and vascular endothelium. The ability of the pulp to produce these is very marked and the essayist cannot help but believe that recovery from a slight infection would readily take place if the surrounding conditions were made favorable. As a matter of fact, the conditions for repair are usually very unfavorable and the granulation tissue is always complicated by the presence of foreign bodies as necrotic cells, red blood-corpuscles and bacteria. A purulent exudation continues to pass through the newly formed tissue which is progressively included in the destruction process and ends in the death of the organ.

Note.—The opinion has been expressed many times that the power of healing is very low in the pulp.

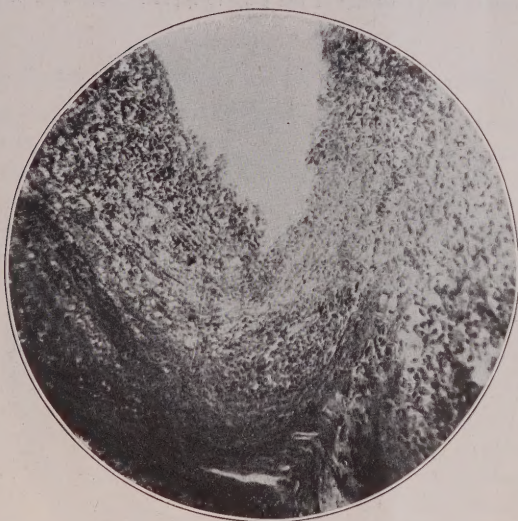


Fig. 52. Evidence of the ability of the pulp to repair. Note area of cicatricial tissue.



Fig. 53. Evidence of the ability of the pulp to repair. Note area of cicatricial tissue.



Fig. 54. Evidence of the ability of the pulp to repair. Note area of cicatricial tissue.

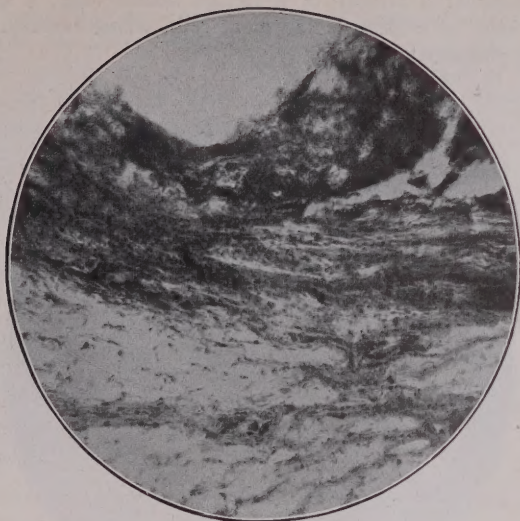


Fig. 55. Evidence of the ability of the pulp to repair. Note area of cicatricial tissue.

(5) *Sharp edges of the pulp chamber in carious cavities.*

Hyperplasia of the pulp:—This is a chronic inflammatory condition, associated with caries that has produced a fairly large perforation of the wall of the pulp chamber and a consequent exposure of the pulp. The margins of the pulp chamber are sharp, and apparently are etiological factors in the formation of a large soft mass of tissue which pushes out into the cavity. The growth consists of:—
 (a) A superficial layer of stratified squamous epithelium which appears to occur there as a result of transplantation of epithelium from the gingivae.

(b) A stroma of fibrous connective tissue which forms a supporting frame-work.

(c) The bulk of the mass is composed of granulation tissue of a low type. The cells are large, and round or oval with large nuclei.

Hopewell-Smith gives the following very excellent description of this tissue:—"It is composed largely of cells of the mesodermic type of variable size, round or oval, derived directly from pre-existing cells, and chiefly concerned in the formation of the bulk of the mass of the new tissue; of the plasm cells of Unna; of many polymorphonuclear hyaline leucocytes; of large mononuclear hyaline leucocytes, which are considered by Metchnikoff to be able to become transformed into fixed connective tissue cells; of 'mast-cells,' so-called; and finally, if

necrotic material is present, or if foreign bodies—eig., a splinter of dentine—exist, of multinucleated giant cells, whose function is somewhat of a phagocytic type.”



Fig. 56. Hyperplasia of the pulp.

(6) *Stimuli which increase the irritability of the dentinal nerves and fibrils.*

From a histological aspect, many different types of calcified formations are added in the course of pathological conditions in the pulp, to the primary dentine. Usually, it is not difficult to distinguish the secondary growth from the first formed dentine. From a calcification that closely resembles the normal dentine, to a tissue that does not seem to have a point in common with it, countless variations may be found and it would be impossible to make a classification that would include all. However, from hundreds of sections prepared by the writer, most types can be included in seven main groups. The work of Black was followed in these investigations, and the essayist wishes to acknowledge the free use of his classification, in part, in this work. The method of preparation applied in the study of the course and delicate branchings of the dentinal tubules was of the greatest value in the work on these different types of secondary calcifications.

(a). *True Secondary Dentine.*

In this group, the secondary formations resemble more than any of the others, the primary dentine. The tubules are continuous with those of the primary dentine and extend to the surface of the pulp. Generally, the tubules are fewer in number, and quite often there is some deviation from the course of the original tubules.

(b). A secondary dentine in which the tubules at first resemble the normal dentine, but gradually become irregular and disappear, succeeded by a clear calcification.

(c). Calcifications attached to the walls of the pulp chamber which are homogeneous throughout. Regarding this type, Hopewell-Smith describes it as follows: "This new kind of dentine has, as its favorite site, the base of the carious excavation into the pulp chamber. It may be irregularly rounded in shape. Its structure in some places conforms to that of a more or less homogeneous ground-glass-like matrix, similar to that of hyaline cartilage; in others it has a distinctly granular or fibrous appearance."

(d). Secondary calcifications which are made up of clear or granular areas and irregular tubules, twig-like tufts and breaks resembling lacunae in bone.

(e). Tumor-like masses of secondary dentine which have grown into the pulp tissue and are attached to the primary dentine by pedicles. Black has stated that these formations are rare.

(f). A secondary deposit, having the appearance of a mass of calcospherites fused together.

(g). Osteo-dentine. A secondary formation in the pulp chamber attached to the primary or secondary dentine and which contains lacunae resembling those of bone, embedded in a granular or tubular matrix. In the description of this type of calcification, according to Black: "The undoubted osseous formations met with in the pulp chamber of the human teeth are very rare. In making this statement I exclude all hard formations in which bone corpuscles are not present. This seems not to have been done by many who have written on this subject; but, on the other hand some writers seem to have called almost all irregular formations osteo-dentine. The great bulk of these have not the slightest resemblance to bone. The cases of osseous formations within the pulp chamber that I have met with, have all presented the general characters of cementum and have been found in the root-canal attached to the dentinal wall or resting upon some irregular formation which separates them slightly from the dentine."

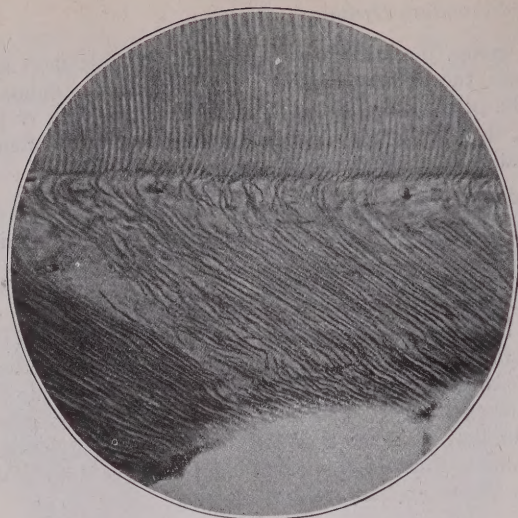


Fig. 57. True secondary dentine.

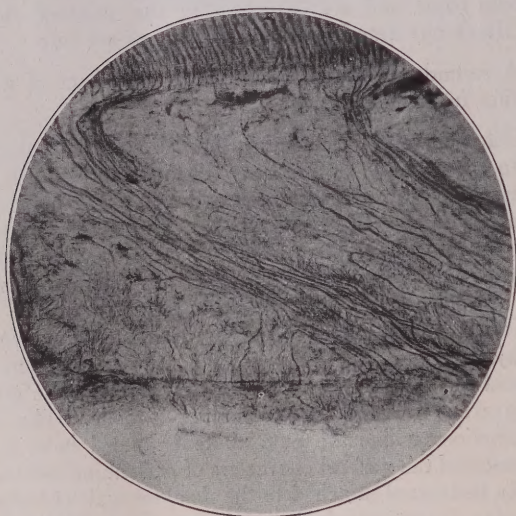


Fig. 58. A form of secondary dentine.

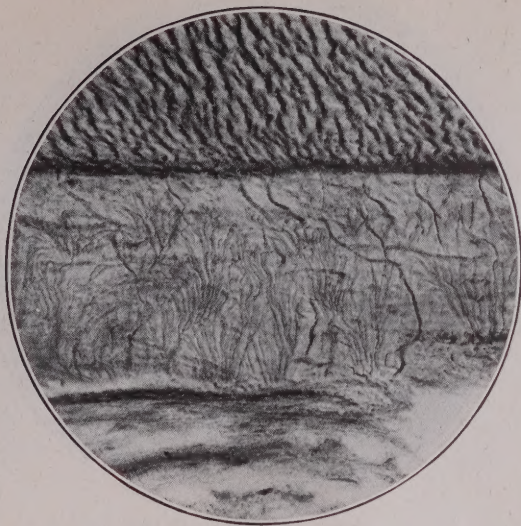


Fig. 59. A form of secondary dentine.



Fig. 60. A form of secondary dentine.

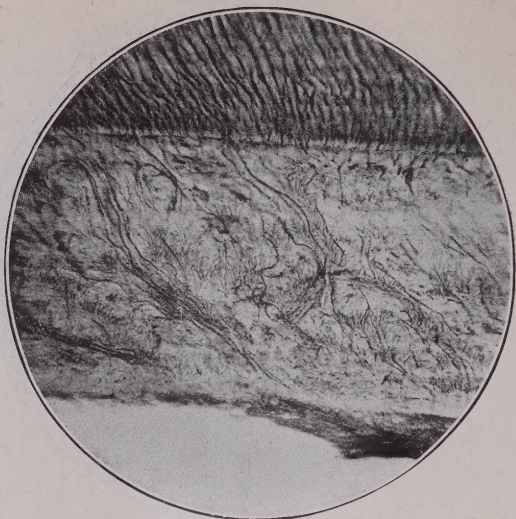


Fig. 61. A form of secondary dentine.



Fig. 62. A dentinal tumor.

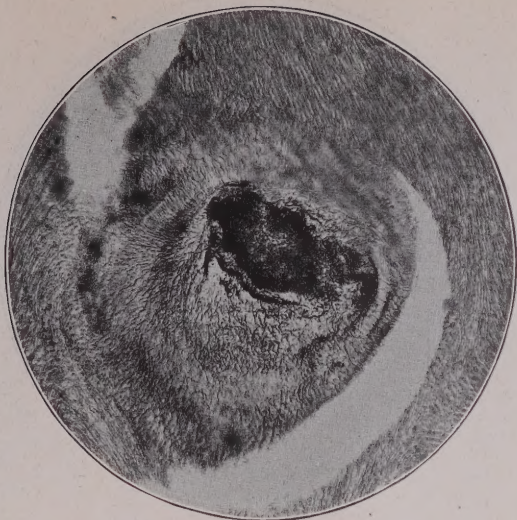


Fig. 63. A dental tumor.



Fig. 64. Osteo-dentine.

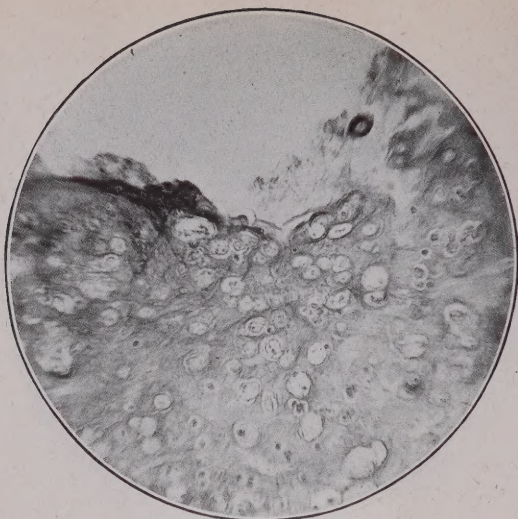


Fig. 65. Mass of fused calcospherites.

7. *Arsenic.*

The changes that occur in the dental pulp as a result of the action of arsenic are as follows:

(a). The endothelium lining the blood-vessels is destroyed and everywhere throughout the pulp a general diapedesis of red cells has occurred. Upon examination of a large number of pulps one cannot help but notice the absence of vessels lined with normal endothelium.

(b). The connective tissue cells appear larger than usual, but the connective tissue fibres and the odontoblasts seem to have undergone no change.

(c). Arkovy states, in regard to its action upon the nervous tissue: "The effects upon the neurilemma is to somewhat increase the number of its nuclei while in the axial part granular destruction of the myelin sets in, and the axis-cylinder begins in various locations to disappear, while in others the notchy tumefaction of the axis-cylinder usually seen only in cases of central lesion, can be plainly made out."

(d). Arkovy found also that arsenic trioxide, when applied to a vital pulp, did not produce coagulation of the tissue.

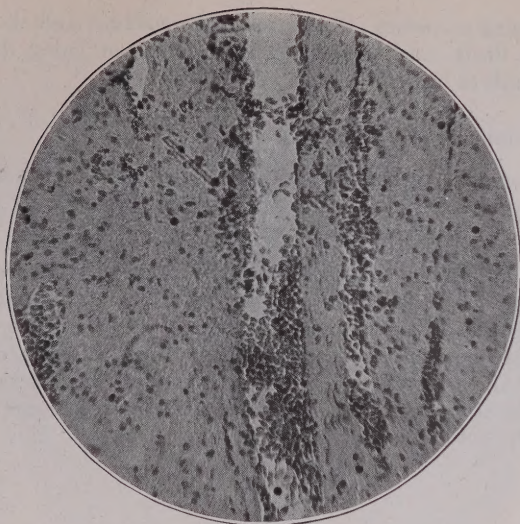


Fig. 66. Changes in the pulp, due to arsenic.

DEGENERATIONS OF THE DENTAL PULP.

Stimulations and depressions of the activity of the cell, by various influences such as toxins, lack of nutrition, increase or lack of internal secretions, bring about a variety of changes, many of which can be distinguished morphologically. There may be an increase in the amount of certain cell constituents such as albuminous granules, glycogen and fat. Then again, new substances may be formed within or outside of the cell, for example, mucin and hyalin. The dental pulp is very subject to degeneration because of its delicate structure and its peculiar environments.

1. *Post-mortem Changes.*

In the normal pulp that has been removed and not fixed for twenty-four hours, the nuclei of the cells take the stain deeply, owing to a diffusion of the chromatin. If the process of fixation is deferred a little later, the nuclei do not stain at all. When bacteria are present in a pulp that has been removed and fixation has not taken place shortly after, many alterations occur due to a multiplication of the bacteria and the liberation of their ferments. Fibroglia fibrils lose

their staining properties rather quickly, the collagen and elastic fibrils retaining theirs much longer. The endothelium lining the blood-vessels tends to strip off.

2. *Areolation of the Pulp.*

This condition is one frequently met with in the study of the pathology of the dental pulp. The early stages are marked by the presence of a few areolae in the matrix.

In the later stages this condition may extend to large areas of the pulp tissue. It seems to be associated with hyperemic disturbances. The pulp cells disappear and extending everywhere through the matrix may be seen very fine connective tissue fibres. According to Black, "These areolae are evidently filled with fluid; hence a kind of oedema of the organ which in the enclosed pulp chamber has probably destroyed the cellular elements."

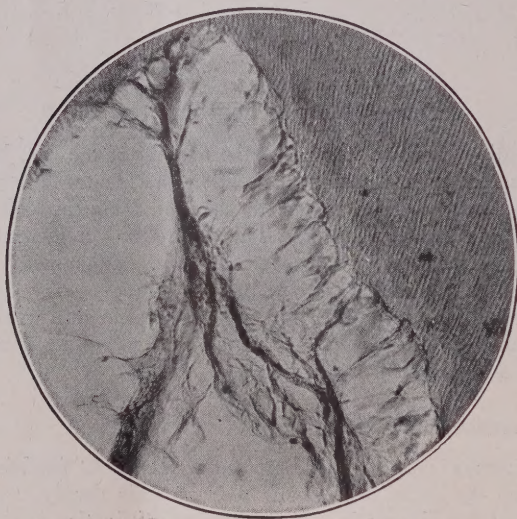


Fig. 67. Areolation of the pulp.



Fig. 68. Areolation of the pulp.

3. *Reticular Atrophy and Fibroid Degeneration.*

In the study of the degenerations of the pulp the essayist had occasion to prepare a great many sections, and numerous examples were noticed where the pulp tissue had almost completely disappeared, and was substituted by a firm fibrous connective tissue in which the nuclei stained very poorly and sometimes not at all. Certain cases were seen in which the pulp chamber contained a single strand of fibrous connective tissue, the odontoblasts, blood-vessels and nerves being absent. In others, there seems to be an increase of the connective tissue fibres in certain areas, forming fairly dense strands, many large spaces lying here and there throughout them. Occasionally the fibres run in parallel straight lines and have the appearance of thickened walls of blood-vessels. Others, again, present throughout the pulp-chamber a fine reticulum of connective tissue fibres, in which the histological appearance of normal pulp tissue cannot be seen anywhere. Hopewell-Smith regards fibroid degeneration as the natural old-age termination of the life of a healthy pulp.

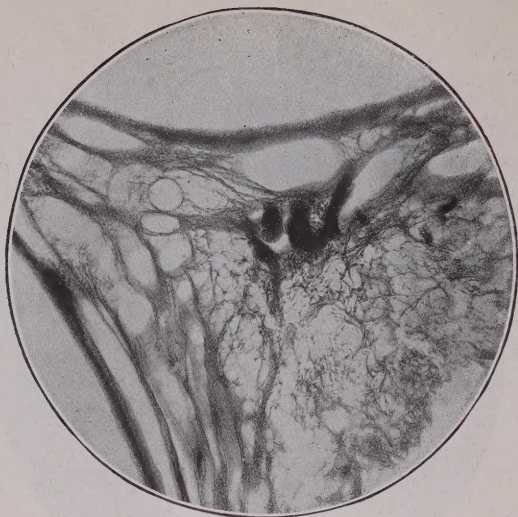


Fig. 69. Fibroid degeneration of the pulp.

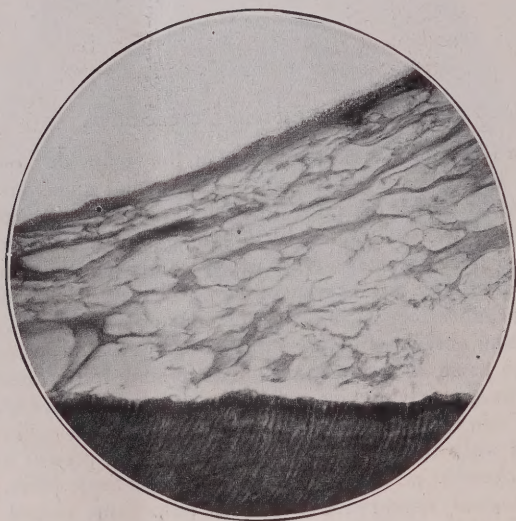


Fig. 70. Fibroid degeneration of the pulp.

4. *Degeneration Evidenced by the Presence of Fat.*

When fat is visible in cells where normally it is absent, its presence there is due to some interference with cell function, as in faulty nutrition or injury produced by toxins. Some observers believe that all such intracellular fat is brought as nourishment to the cells through the blood and lymph, and owing to cell degeneration, cannot be utilized. Others hold that it arises directly within the cell from a change of certain of its constituents into fat. Degenerations of the pulp associated with the presence of fat in the tissue cells are not common.

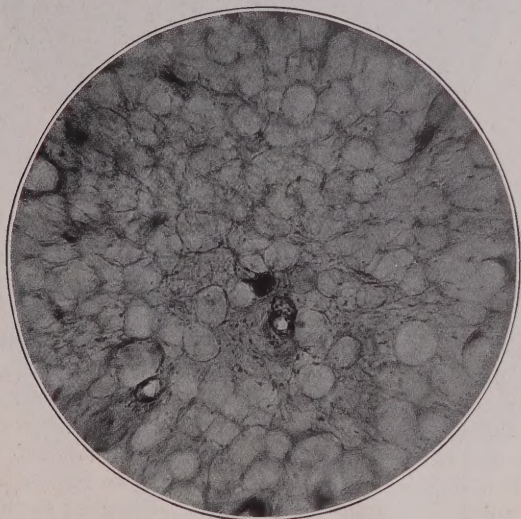


Fig. 71. Cell degeneration evidenced by the presence of fat in the pulp.

5. *Mucoid Degeneration.*

In the embryonal connective tissue of the dental pulp, mucus occurs between the collagen fibrils produced by the cells. Mucus contains a group of nitrogenous, albuminous substances known as mucins, which are coagulated by boiling and precipitated by acetic and dilute mineral acids. They swell up with water, forming a slimy stringy substance. With hematoxylin, mucus substances usually stain a pale grayish blue to intense blue. In certain degenerative conditions of the pulp, areas have been noted, sometimes quite large, in which are present fine stringy substances that have the characteristic staining properties of mucus and which the writer believes to be a mucoid degeneration.

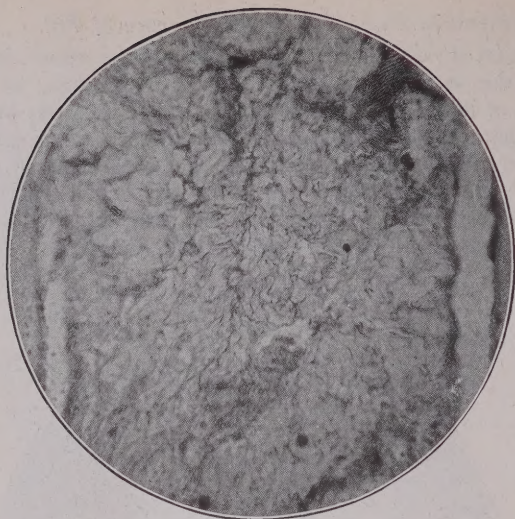


Fig. 72. Muroid degeneration of the pulp.

6. *Hyaline Degeneration.*

The term hyalin is applied to a body of albuminous nature which is distinguished from the other substances of the hyaline group such as mucus, colloid and amyloid, chiefly by its appearance, its homogeneous character and its high refractive power. It is not coagulated by acids and remains unchanged in water, salt solution, alcohol or ether. It is distinguished by its marked affinity for the acid anilin dyes as eosin, orange and acid fuchsin. According to the work of the essayist, it is not commonly seen in the degenerations of the pulp.

(a). *Hyalin in Connective Tissue.*

Under certain conditions the collagen fibrils of connective tissue became unrecognizable by a deposit of hyalin between them. In connective tissue that has been newly formed or where it has undergone sclerotic changes, this is frequently seen.

(b). *Hyalin in Plasma Cells.*

Hyaline droplets of various sizes frequently develop in the cytoplasm of plasma cells. They frequently become extra-cellular through the degenerations of the cells, and are often called "Russell's fuchsin bodies." They are frequently present in chronic inflammation of the dental pulp.

(c). *Hematogenous Hyalin.*

Mallory asserts: "Necrotic cells and fibrils and red blood-corpuscles bathed in serum frequently undergo a hyaline change due to the formation of fibrin. In this way, hyaline masses of various sizes and shapes may be formed in the blood-vessels, (hyaline thrombi), and in the tissues."

(d). *Hyalin in Blood-Vessels.*

Hyalin occasionally occurs in the walls of the blood-vessels in the form of multiple droplets which fuse together to form homogeneous hyaline walls. Capillaries frequently become enveloped in this manner.

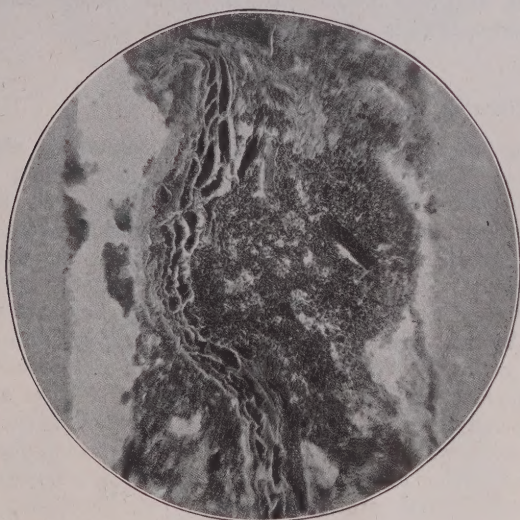


Fig. 73. Hyaline degeneration of the pulp (class A.)

7. *Necrosis.*

When death occurs suddenly to cells, singly or in groups, while the surrounding tissue retains its connection with the body, the process is called necrosis. When the injurious influences lead to gradual death of cells, the term used is necrobiosis. The causes of necrosis are numerous.

The destruction of cellular material in the dental pulp may take place in degenerative processes which occur in certain cell-complexes

ending in their separation from the rest of the body. Death of circumscribed portions of tissue may result from the action of toxins of many sorts. When the blood supply is cut off, which so frequently happens in many disturbances in the circulation of the pulp, necrosis of the tissues ensues.

Certain changes in the nucleus and cytoplasm are characteristic of necrotic cells. One of the characteristics of dying tissue is a progressive disappearance of the chromatin of the nucleus, (karyolysis). The nuclei fail to take the stain normally. They may contract into a variable mass of more or less coherent fragments arranged in the most irregular manner, and which stains intensely, (pyknosis) or become broken up into amorphous particles (karyorrhexis). The cytoplasm may stain feebly with reagents that normally affect only the nuclei, or it may become coagulated and homogeneous, staining deeply with acid dyes.

8. *Calcification and Calcareous Deposits.*

During pathological conditions certain substances may attract lime salts. Calcification may take place in the inert interstitial matter between the cells, but not in the living cells themselves. Necrotic tissue anywhere may become calcified. Many different theories have been brought forward to explain the phenomenon. Adami writes: "Obviously it is not a precipitation of the salts normally present in the affected areas, the lime salts are brought to the part by the lymph and in dead or dying cells or in the interstitial material of low vitality are rendered insoluble and deposited. The chemical process underlying this, appears in some cases at least, to be that a fatty degeneration of cells is accompanied by the liberation of fatty acids which combine with the calcium in the lymph to form compound calcium soaps. In this combination the weaker fatty acids are phosphoric and carbonic acids with the subsequent deposit of insoluble calcium phosphate and carbonate in the dead tissues."

Old infarcts, chronic inflammations and suppurations which have been calcified are frequently seen. Lime salts are deposited in various homogeneous substances, the products of secretion and degeneration. In the arteries, calcareous infiltration may occur following hyaline and fatty degeneration.

Mallory believes that fat products play a part in the process.

Professor Wells, of Chicago, has shown that hyaline cartilage and hyaline-degeneration material possesses a very great affinity for calcium.

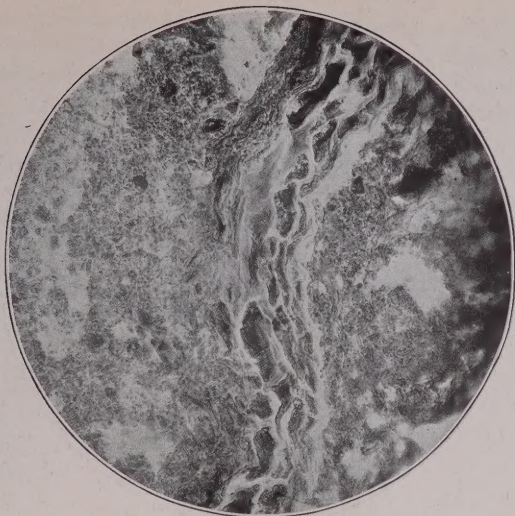


Fig. 74. Hyaline and calcareous degeneration of the pulp.

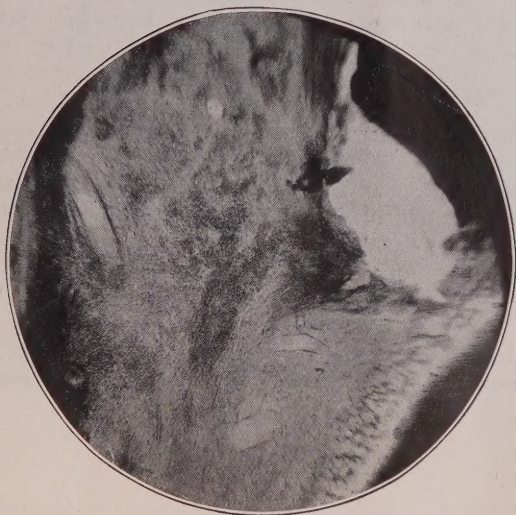


Fig. 75. Calcareous degeneration of the pulp.



Fig. 76. Total calcification of the pulp.

One of the most common types of calcification in the pulp is the so-called pulp nodule. These formations have a great variety of shapes and appear singly or in groups. They are classified as follows:—

(1). Irregular or serrated type.

(2). Smooth—In some of these oval lime bodies, lamellæ are observed in which the layers are arranged concentrically. When viewed under high power, very fine canals are seen, radiating from the centre of the formation through the different lamellæ, and somewhat resemble the canaliculi of bone.

(3). Fusiform. Deposits are often met with in the root canals. They are, as a rule, fusiform or oval in shape.

(4). Jointed. Sometimes these masses attain a large size and become jointed together exercising pressure on the structures in the pulp.

CALCOGLOBULIN DEPOSITS.

Concerning these irregular masses, which are so frequently found associated with inflammatory conditions, Black has written: "This

formation is associated with the formation of what are known as pulp nodules. It possesses the same form of elements common to the pulp-nodule, including the forms of the calcospherite, but is soft enough to be readily cut with the knife in the preparation of sections, while the pulp-nodule is very hard. It has been present in a number of the pulps I have cut, always in the inflamed portion, and usually near the point of exposure, often lying immediately beneath the layer of odontoblasts, but occasionally much deeper within the tissues of the pulp. It usually occurs in irregular masses, occasionally of considerable size; and scattered about these, there are generally a number of small globular forms, many of which have the onion-like layers of the calcospherite distinctly marked."

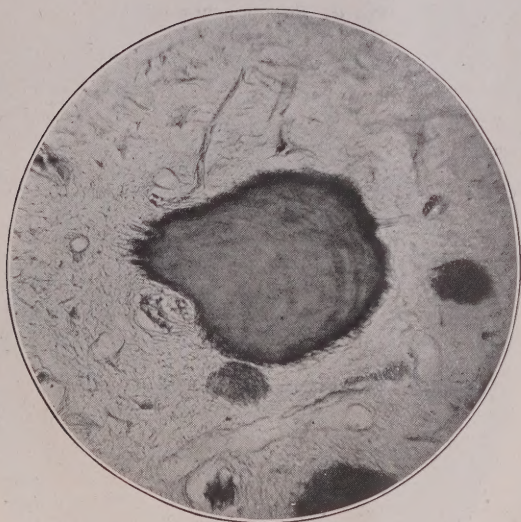


Fig. 77. Serrated pulp nodule.



Fig. 78. Smooth pulp nodule.

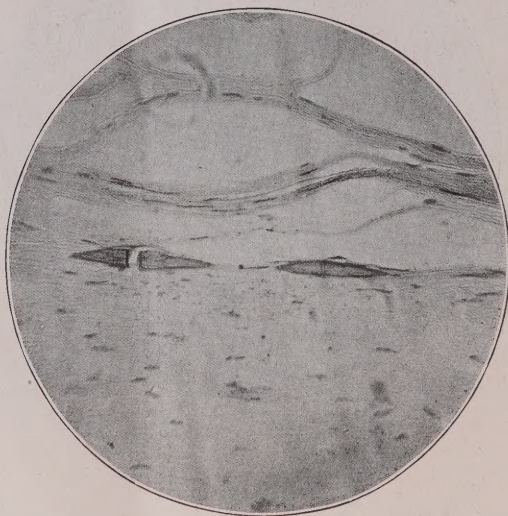


Fig. 79. Jointed pulp nodule.



Fig. 80. Fusiform pulp nodule.

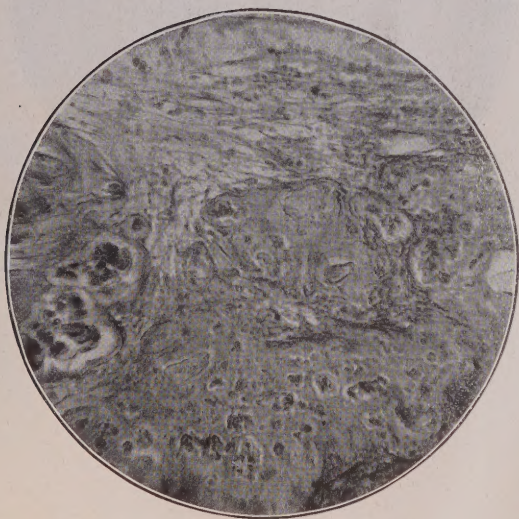


Fig. 81. Calcoglobulin deposit.

CALCOSPHERITES.

Small spherical calcific bodies are occasionally found in the pulp tissue and they have been called calcospherites. Black has compared their appearance to that of a cross-section of a tiny onion.

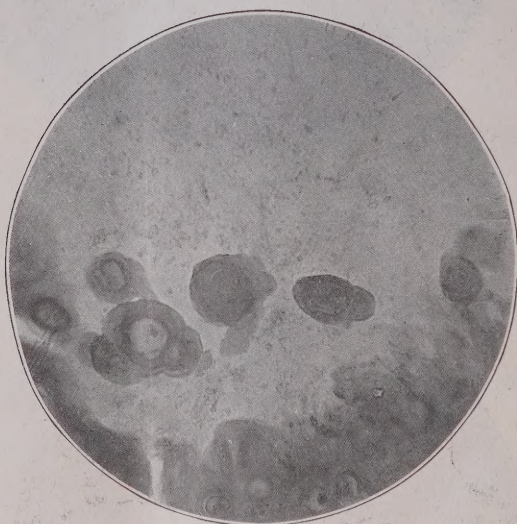


Fig. 82. Calcospherites.

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Any Dentist in Canada who feels that he has any original work worthy of publication is requested to forward it to the Foundation.

The photomicrographs illustrating these bulletins were made by Professor G. R. Anderson, of the University of Toronto and the Royal College of Dental Surgeons.

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Theory and Practice of Partial Denture Service, with Special Reference to a Graphic Method of Design

W. E. Cummer, D.D.S.
TORONTO, CANADA

*Condensed notes supplementary to lectures and demonstrations on the
above subject, given before The Society of Dental Science, New
South Wales, The Chicago Dental Society, The Academy
of Dental Science, Boston, The Canadian and
Ontario Dental Convention, and The
Northern Ohio Dental Society.*



Bulletin Number Five

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May, 1922

An Outline of the Theory and Practice of Partial Denture Service

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ROYAL COLLEGE OF DENTAL SURGEONS, TORONTO.

EXPLANATORY NOTE.

1. Partial Denture **SERVICE**, includes (a) **Theory**, defined as "the classified knowledge of the subject" (Wilson) and (b) **Practice**, the use of this classified knowledge in guiding the hands in the various handicraft-operations necessary in the replacement of lost teeth.

2. The **THEORY** of partial denture service is made up chiefly of a working knowledge of the

(a) Natural structures and functions to be restored (gross and minute), including their probable behavior when subject to unusual stresses.

(b) Standardized parts, which when brought into proper juxtaposition, will result in an appliance which will

1. Restore structures and functions as maybe by human agency.

2. Prevent further injury to structures and functions.

(c) Prevention of injuries to these parts—

1. Injuries which naturally result in the loss of teeth;

2. Injuries from improperly designed and constructed artificial parts.

3. The **PRACTICE** of Partial Denture Service. Having acquired, and mentally classified the above theoretical principles, these may be used as a guide to correct manipulation in the Practice of Partial Denture Service. Practice is made up of four stages: Design, Construction, Installation and Maintenance.

4. **Design**. A mental or graphic picture must precede all engineering construction. In Partial Denture design the theoretical principles are made use of as needed in the development of design. The main item of practical value of this demonstration is that of a mental and graphic technique for the development of any design for any combination of teeth in four simple stages.

5. **Construction**. Having developed mentally or on paper the correct design, the next step is that of actual construction. Accuracy, lightness, small bulk as possible, rapidity, ease, and low cost are of primary importance. In the opinion of the writer, much research and invention are needed here.

6. **Installation**. Many a fine piece of well designed and constructed Prosthetic work is become a failure for the sole reason of lack of care in installation. Hence the importance of this step.

7. **Maintenance and Repair**. Many a piece of well designed, constructed and installed Prosthetic work becomes a failure for the sole reason of improper maintenance and prompt necessary repairs. The patient here divides the responsibility with the dentist. Hence also the importance of this step.

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PARTIAL DENTURE SERVICE

(continued)

ROYAL COLLEGE DENTAL SURGEONS

THEORY OF PARTIAL DENTURE SERVICE :- A Working Knowledge of:-

A. RESTORATION

1. Structures to be restored { 1. Teeth
2. Associate parts.
2. Functions to be restored { 1. 1st step in digestion { 1. Mastication
2. Speech & Voice { 2. Insalivation
3. Expression. { 3. Deglutition.

B. STANDARDIZED PARTS, WHICH, IN PROPER ASSEMBLY, WILL :-

3. Restore Structure and Function as may be by Human Agencies
4. Prevent further injuries to Structure and Function as may be by Human Agencies

} See Chart
No. 2.

C. PREVENTION

5. Injuries as result of extraction by good appliances preventable { 1. Drifting
2. Exfoliation
3. Excessive Stress & Wear
4. Stagnation.

6. Injuries as result of faulty appliances preventable by Good appliances.
(Presupposing Healthy Mouth)

STRUCTURES

1. Enamel, Dentine and Cementum :- intensive caries production, erosion and wear, from capillarity
2. Gingivae :- impingement and interference.
3. Mucosa and subjacent bone :- overload.
4. " " " " :- strangulation.
5. Pericementum and mucosa, with subjacent bone :- overload.
6. Pericementum :- overload.
7. " " :- torque, vertical.
8. " " :- torque, horizontal.
9. " " :- incline plane, (wedge) mesio-distal
10. " " :- incline plane, Bucco-lingual.
11. " " :- incline plane, M.D. B.L.
12. " " :- incline plane, axial.
13. " " :- lever 1st class (shears)
14. " " :- " 2nd " (nut cracker)
15. " " :- " 3rd " (flask tongs)
16. Pericementum, combinations of all mechanical advantages.
17. Dental pulp and periapical tissues, various injuries.
18. Cheeks, tongue and soft tissues, impingement and irritation, leading possibly to malignancy.

} 3
OUT
OF
5
M.A.

FUNCTIONS

19. Mastication and ultimate digestion, various injuries.
20. Speech and voice, lisping, thick speech and etc.
21. Hearing, interference with.

BOTH STRUCTURES AND FUNCTIONS

22. Any or all of above injuries, from lack of systematic maintenance.

Figure No. 1. Duplicate of chart as shown. Note three divisions of theoretical knowledge—A, B, C, with detail.

THEORY.

1. RESTORATION.

It is manifestly impossible to attempt the restoration of structures and functions wholly and partially lost without an intimate knowledge

of each of these, both gross and minute. The necessity of subjecting both the teeth and associate tissues to unusual stresses requires a knowledge of the probable behavior of these tissues under these stresses, in order to utilize these tissues as much as possible and avoid overload. Incidentally the dental profession requires a very considerable amount of data on this probable behavior of tissues under various loads, from research investigation not yet done.

2. STANDARDIZED PARTS.

In manufacturing practice, standardized products are assembled by the juxtaposition of standardized parts by manufacturing processes. This juxtaposition may be varied for special needs or uses; for example a variation in the juxtaposition of parts of an automobile will result in a variety in the product, with a proportion of the parts identical in each.

In partial denture design the process is a mental or mental-graphic one with a mental store house of six classes of standardized parts located in the mind of the Dentist as a result of his theoretical studies. This forms the second branch of the theory of partial denture service as may be noted in detail in figure No. 2 (page 5).

3. BASES, ATTACHMENTS, TEETH.

The *base*, or that part in contact with the mucosa, includes the saddles and parts connecting saddles, discussed under Design, step 1 and 2. Vulcanite as a material is indicated in cases which may require rebasing, especially after recent extraction. The *attachment* here describes that element which joins the teeth to the base, usually vulcanite, occasionally gold (with tube teeth, crowns, or similar). The *teeth* used are usually vulcanite pin teeth, detachable facings or tube teeth. The sulcus angle of these teeth should be made to correspond with that of the remaining teeth, and all of the detail of marginal and transverse ridges, grooves, etc., should be present to allow the escape of cut food and prevent overload.

4. RETENTION, AND OBJECTIVES IN RETENTION.

All that is required in retention of any artificial restoration is fixation sufficient to oppose gravity or the displacing effect of mastication. Gravity in uppers is very slight, a matter of ounces, and the bulk of masticating force tends to seat the denture in position. Hence only a slight retentive force is necessary, except in small removable bridges, which may be swallowed, in which the retentive force should be positive, requiring some effort to remove.

Obviously the piece should be retained so far as possible at the centre of gravity. In addition to this the following objectives may be noted:—

THEORY OF PARTIAL DENTURE SERVICE (Concluded) **PARTIAL DENTURE SERVICE** Chart '2. ROYAL COLLEGE DENTAL SURGEONS

STANDARDIZED PARTS

1. **BASE**
 1. Selection
 2. Construction
 3. Covering upper parts for supporting without an occlusal support
 4. Construction of base
2. **ATTACHMENT**
 1. Gold
 2. Vulcanite
3. **TEETH**
 1. For retentive attachment
 2. For gold attachment
4. **RETAINERS**
 1. Rigid
 2. Flexible
5. **CONNECTORS**
 1. Simple
 2. Compound
6. **OCCUSAL RESTS**
 1. Recessed
 2. Surface

RETAINERS (A Partial List)

- DIRECT RETAINERS**
- Non-precision**
- Simple**
1. Clasp
 2. Orth. single and multiple
 3. Quilling attachment
 4. Staple attachment
- Compound**
1. Arch attachments & similar
 2. Stud, single and double
 3. Ring & stud, single & double
 4. Clasp
- Surface**
1. 14 gauge wire (rounded)
 2. Cast
- Recessed**
1. 14 gauge wire obliquely recessed inlay or similar
 2. Cast to fit oblique recess
- Indirect Retainers (Oblique & 2 only)**
- Surface**
1. Vertical occlusal rest on cusp, prem, molar, buccal or lingual
 2. Right hand loop M.B.L.L.A
- Recessed**
1. 14 gauge oblique wire recessed in inlay or similar
 2. Cast oblique recessed in inlay or similar

CLASPS (A Partial List)

- WROUGHT CLASPS**
- Wire**
- Bond**
- CAST CLASPS**
- Wire**
- Bond**
- COMPOSITE CLASPS (Wrought & Cast)**
- Wire**
- Bond**

Figure No. 2. Chart of standardized parts as shown. A working knowledge of these having been acquired, their juxtaposition may be easily accomplished as noted in text, in four simple stages—

1. Saddles.
2. Parts connecting saddles.
3. Retention.
4. Occlusal rests.

- (a) Use of simple retainer (as clasps) instead of compound retainers, (as Roach attachments, etc.) as far as possible for both preventive and economic reasons.
- (b) An effort to use two only retainers with fulcrum line (imaginary line between direct retainers) passing through the centre of gravity of restoration (Class 1-2-3) with or without indirect retainers. (See figure No. 3.)
- (c) The use of three or more direct retainers if paired teeth may not be found opposite, with fulcrum line in centre of gravity, or if a splint-support for teeth of impaired pericementum is required.

5. DIRECT RETAINERS.

Retainers are subdivided direct and indirect, direct retainers such as clasps and similar applying the retentive force directly at the point of application. As noted figure No. 2 these are *simple* (as clasps, cribs, etc.) and *compound* (as Roach, ring and stud, etc.). The simple retainers are preferable over compound retainers because no

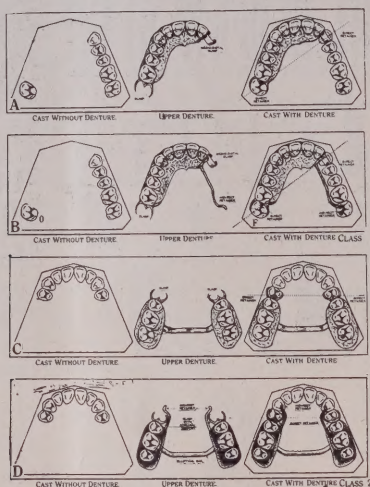


Figure No. 3. Indirect Retention.

A. shows a restoration which would be unsuccessful because the fulcrum line lies to one side of the centre of gravity of the piece, and the saddle in the cuspid region would be unstable.

B. shows the restoration A corrected by a 14 gauge extension reaching to the second molar at a horizontal point on the occlusal surface at which the articulation will admit. This brings the centre of gravity coincident with the fulcrum line, and stabilizes the unsupported part of the saddle (the cuspid region). The above is an example of class one with direct retainers diagonally opposite.

C., a class two restoration (with direct retainers diametrically opposite); unsuccessful because the fulcrum line lies outside the centre of gravity.

D. same as C, corrected by indirect retention bringing the centre of gravity coincident with the fulcrum line. As noted figure No. 5, indirect retainers are of various types, contact only, and also carrying teeth, restoring spaces, etc.

cutting of tooth tissue is necessary. Compound retainers are indicated when excavation of tooth tissue is either necessary or has been already done.

6. INDIRECT RETAINERS.

Direct retainers should be ordinarily two in number and should be placed directly opposite with an imaginary line joining them (fulcrum line) passing through the centre of gravity of the restoration. Frequently this is impossible because the fulcrum line joining the two teeth adjacent to the edentulous space may lie outside the centre of gravity of the restoration. Hence an extension brought into contact with a suitable tooth remote from the unsupported part of the restoration will bring the fulcrum line to the centre of the piece. These extensions are called indirect retainers as noted Figure No. 3.

7. CONNECTORS.

In cases in which the pressure of mastication is either wholly carried by the teeth or roots or divided between these and the mucosa, a 14

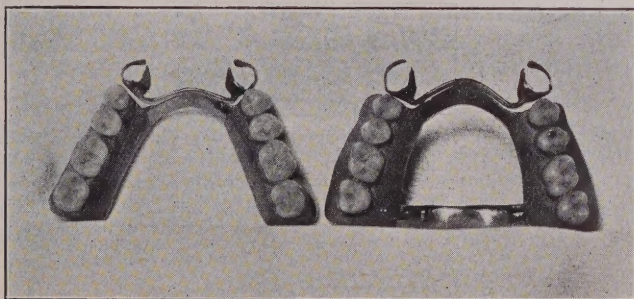


Figure No. 4. A simple non-rigid connector (W. A. Giffen) of 18 gauge elastic wire. An independent saddle movement is here secured, but without support from adjacent teeth.

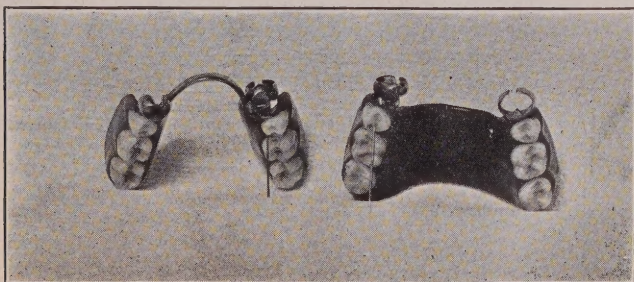


Figure No. 5. A compound non-rigid connector (Dresch). Mr. Dresch has stated that, by the use of vulcanized rubber between the links pressure may be divided between teeth and mucosa. Models furnished kindness Dr. L. F. Furnas, Cleveland, Ohio.

gauge wire soldered to the clasp, or other retainers, placed usually in the embrasure, (see Fig. 11) and attached by solder to the balance of the frame work may be used.

Should, however, for such causes as flabby mucosa, few remaining teeth, or similar, it may be deemed unsafe to divide the pressure for fear of overload of the pericementum, non-rigid connectors may be used. Examples of two types are shown, rigid and non-rigid. Figure No.'s 4 and 5.

8. OCCLUSAL RESTS.

Occlusal rests if used transmit all or part of the pressure of mastication to the teeth and pericementum upon which they may rest. These are of various types as noted (Figure 2) for various purposes, as noted hereinafter.

9. PREVENTION OF DRIFTING, EXFOLIATION, EXCESSIVE STRESS, WEAR AND STAGNATION.

These changes following the loss of teeth are usually preventable



Figure No. 6. An instance of progressive drifting and exfoliation following extraction with increase of traumatic occlusion.

- Before extraction.
- Immediately after extraction, no traumatic occlusion.
- Lower molar tipping forward and separating both upper and lower, bicuspid driving upper bicuspid distally.
- The same condition only considerably worse, with exfoliation.
- and (f) The same with separation of upper anterior. At any stage these progressive conditions could have been checked by well designed partial restorations.

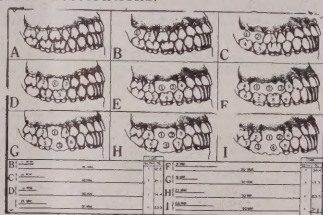


Figure No. 7. Excessive stress and consequent wear. The approximate loss s in area, hence masticating efficiency is indicated above.

- Complete Denture.
- One tooth at the end of a series, loss approximately 12.2%.
- Two teeth, loss approximately 21.1%.
- One tooth in centre of a series, loss approximately 23.3%.
- Two teeth, loss approximately 23.3%.
- Three teeth, loss approximately 34.4%.
- Two teeth, loss approximately 17.7%.
- Three teeth, loss approximately 23.3%.
- Four teeth, loss approximately 31.1%.

In each case these losses indicate the same stress heretofore carried by the complete denture and now assumed by the remaining teeth. It might also be noted that, when a tooth is extracted from the centre of a series, the function of five others is interfered with as in (d), the function of Nos. 2-3-4-5 is interfered with, with complete loss of function of the extracted tooth No. 1.

by the immediate insertion of well designed partial restorations, and are as follows:

1. Drifting, limited or extensive, usually with and occasionally without traumatic occlusion.
2. Exfoliation, limited or extensive, usually with or occasionally without traumatic occlusion.
3. Excessive stress and consequent wear on remaining teeth.
4. Stagnation of non-occluding teeth.



Figure No. 8. A sample of stagnation, with Nature's tooth brush (e.g., the passage of food over teeth driven by teeth and occlusion) absent. Especially with a lack of salivary balance, the above is apt to occur. Note difference, left and right elevation of cast.

10. LIST OF MOST FREQUENT CAUSES OF INJURY TO STRUCTURES, AND INTERFERENCE WITH FUNCTIONS AS COMMONLY FOUND IN PARTIAL DENTURE DESIGN AND CONSTRUCTION, INSERTION, AND MAINTENANCE (IN PART).

Here follows a list in part as enlarged from 22 items, Figure I, No. 6 (injuries as the result of faulty appliances), with most frequent examples of each. It may be noted that, capillarity, impingement, interference, and the three out of the five mechanical advantages (torques, levers and incline planes) include all of these destructive forces.

STRUCTURES.

11. ENAMEL, DENTINE AND CEMENTUM, INTENSIVE CARIES PRODUCTION, EROSION AND WEAR.

- (a) Capillary retention against enamel, (faulty or at fissures) from clasps, occlusal rest, or pads causing intensive caries production.
- (b) Capillary retention against dentine by clasp, pad, or other constructional parts, causing intensive caries production.
- (c) Capillary retention against cementum by clasps, base, or other constructional parts, causing intensive caries production.
- (d) Clasps and other parts over inlay margin, causing intensive caries production.
- (e) Clasps and other parts over eroded areas, causing further erosion, caries or both.
- (f) Arasion, usually from porcelain in overload relation to abraded teeth.

- (g) Attrition, usually from natural teeth in overload.
- (h) Use of compound retainers rather than simple, resulting in unnecessary destruction of tooth tissue.
- (i) Unnecessary number and contact area of direct retainers.

12. GINGIVAE, IMPINGEMENT AND INTERFERENCE.

- (a) Impingement against gingival margin, or septal gingivae by clasps, etc.
- (b) Impingement against gingival margin, or septal gingivae by saddle and other constructional parts.
- (c) Impingement against gingival margin, or septal gingivae by "settling" clasps and saddles, especially after recent extraction.
- (d) Interference from unprotected gingival margin and septal gingivae from lack of occlusal protective contours, such as marginal ridges, cusps, etc.
- (e) Interference from unprotected gingival margin, and from septal gingivae from lack of axial protective contours.

13. MUCOSA AND SUBJACENT BONE, OVERLOAD.

- (a) Overload from small saddle area in proportion to mastication area, and pressure, without occlusal rests.
- (b) Local overload, improper muscle trimming, saddle outline, etc.
- (c) Local overload from incorrect forecast of compensation for hard areas, and settling.
- (d) Overload of mucosa from relation of direct retainer and mucosa with too much pressure on mucosa.

14. MUCOSA AND SUBJACENT BONE, STRANGULATION.

- (a) Parallel wrought and cast clasps, connectors, and compound retainers which do not release after pressure applied from too tight construction, etc.
- (b) Clasps with excess towards gingival cone.
- (c) Indirect retainers adjusted too tight.
- (d) Overloads on mucosa as above.
- (e) Relations between saddles and direct retainers giving mucosa too much pressure.

15. PERICEMENTUM AND MUCOSA, WITH SUBJACENT BONE, OVERLOAD.

- (a) Local overload, from warpage in construction and too great pressure at one or more points.
- (b) Overload, from lack of escape grooves, with flat cutting contacts rather than line contacts.
- (c) Overload from all constructional parts preventing exact central occlusion.

16. PERICEMENTUM, OVERLOAD.
- (a) Overload from occlusal rests, from expected absorption (especially after recent extraction) with no rebasing.
 - (b) Overload from large saddle area, with occlusal rests.
 - (c) Overload from medium saddle area, soft mucosa, with occlusal rests.
 - (d) Clasps without occlusal rests too heavy to admit of "slip" especially with soft mucosa.
17. PERICEMENTUM TORQUE, VERTICAL.
- (a) Cast clasps too wide on free saddle.
 - (b) Cast clasps too thick on free saddle.
 - (c) Cast clasps (B.L.) wide body on free saddle.
 - (d) Cast clasps (M.D.) too wide at free ends and attached to free saddle.
 - (e) Cast clasps (B.L.) too thick at free ends and attached to free saddle.
 - (f) Cast clasps (L.A.) attached to free saddles as above.
 - (g) Reinforced wrought clasp attached to free saddle as above.
 - (h) Improper relief on all clasps (E.G. right angles to fulcrum line).
18. PERICEMENTUM, TORQUE, HORIZONTAL.
- (a) Cast clasps on single teeth.
19. PERICEMENTUM INCLINE PLANE, (WEDGE) MESIO-DISTAL.
- (a) Interfering embrasure hooks above contact point.
 - (b) Connectors improperly soldered to free end of clasps.
 - (c) Too much solder, connector to clasp.
 - (d) Occlusal rest too short and on incline plane.
 - (e) Improperly placed rigid connectors on leaning teeth.
 - (f) Improperly placed clasp bodies.
 - (g) Rigid 2-3 loops too short.
20. PERICEMENTUM, INCLINE PLANES, BUCCO-LINGUAL.
- (a) Indirect retainers on incline planes without occlusal rests on direct retainers.
 - (b) Improperly placed rigid connectors on leaning teeth.
 - (c) Improperly placed clasp bodies.
 - (d) Skeleton work too rigid.
21. PERICEMENTUM, INCLINE PLANE, M.D.B.L.
- (a) Teeth interfering with occlusion.
 - (b) Teeth interfering with articulation.
 - (c) Parts interfering with occlusion.
 - (d) Parts interfering with articulation.

- (e) Shrinkage and distortion of metallic frame-work.
- (f) Contours too full, inlays, crowns, etc.

22. PERICEMENTUM, INCLINE PLANE, AXIAL.

- (a) Clasp above or below line of widest cross section.
- (b) Rebound of displaced mucosa, with relation of direct retainers and mucosa too close without occlusal rests.

23. PERICEMENTUM, LEVER 1ST CLASS.

- (a) Indirect retainers too tightly adjusted.
- (b) Cast multiple clasps on single groups of teeth.
- (c) Indirect retainer too close to fulcrum line.
- (d) Teeth set outside ridge.
- (e) Class 4 cases with free saddle on soft mucosa.

24. PERICEMENTUM, LEVER 2ND CLASS.

- (a) Cast multiple clasps on single groups of teeth.

25. PERICEMENTUM, LEVER 3RD CLASS.

Indirect retainers, no occlusal rest on direct retainer. (Remainder of mechanical advantages, e.i. screw and pulley, not found).

26. PERICEMENTUM, COMBINATIONS OF ANY OR ALL MECHANICAL ADVANTAGES.

- (a) Cast clasps with rigid connectors on flabby mucosa, without provision for correlation of movement of saddle and anchor tooth.

27. THE DENTAL PULP, PERIAPICAL TISSUES, VARIOUS INJURIES.

Because of the interdependence of the dental pulp, pericementum, dentine, enamel, cementum and gingival tissues, injuries to the dental pulp, followed by diseases of the dental pulp, may occur from any or all of the foregoing causes.

28. CHEEKS, TONGUE AND SOFT TISSUE, IMPINGMENT AND IRRITATION, LEADING POSSIBLY TO MALIGNANCY.

- (a) Improper overhang to prevent tongue and cheeks biting.
- (b) Positioning of constructional parts not close enough to prevent irritation to tongue and cheeks.
- (c) Improper finishing, rounding off of sharp edges, elimination of feather edges, etc., (should include a study of the microscopy of the polished and aseptic surfaces).

FUNCTION.

Injuries may result from lack of application of all known principles, especially in:

29. MASTICATION AND ULTIMATE DIGESTION, ETC., VARIOUS INJURIES.

- (a) All missing teeth and surfaces not supplied, (for example with special occlusal pads to secure greatest masticating surface).
- (b) Lack of anatomical articulation on partials, (various mechanical advantages as before mentioned).
- (c) Lack of positive retention in small pieces and danger of swallowing of piece.

30. SPEECH AND VOICE, LISPING, THICK SPEECH, ETC.

- (a) Parts crossing ahead of bicuspid to be between rugae or failing this, wide flat cast or swage pieces (avoiding lispings, etc.)
- (b) Parts crossing distal to first molar, bar or similar not crossing approximately opposite to the second molar, causing thickening of speech.
- (c) Parts not close to mucosa. (Causing both lispings and indistinct enunciation).

31. HEARING, INTERFERENCE WITH.

- (a) Neglect of sufficient intermaxillary distance in restoration. (may interfere with opening of meatus by condyle tipping back and causing obstruction. See literature, Monson, Wright and others).

BOTH STRUCTURE AND FUNCTION.

Almost all of the foregoing injuries to structure and function may occur, or may be aggravated through breakage, settling, or other contingencies difficult or impossible to foresee. *After* insertion these may be prevented by proper inspection and maintenance including the following:

32. MAINTENANCE, (THE PATIENTS PART).

- (a) Cleansing five times per day.
- (b) Saliva flush.
- (c) Removal at night.
- (d) Use of notification system for periodic examination furnished by dentist.
- (e) Prompt repairs if necessary.
- (f) Study of suitable literature provided by dentist.

PARTIAL DENTURE SERVICE

Chart "3.

ROYAL COLLEGE DENTAL SURGEONS

PRACTICE OF PARTIAL DENTURE SERVICE :- Choice and execution of :-

(Presupposing Mastery of Theory and of Necessary Handicraft and with mouth "made ready")

PRELIMINARY

1. General Examination
(If required, by Physician)

2. Dental Examination

1. Charts
2. Study Models
3. Both or neither
4. Order of Examination
(With or without radiographs)

1. DESIGN

1. Saddles
(Allocation Load to Mucosa)

2. Parts connecting saddles

3. Direct and Indirect
Retention and Connectors

4. Occlusal Rests
(Allocation of load to teeth
and their pericementa)

1. Skeleton
2. Continuous
3. Upper Palatal
4. Combination of Above

1. Cast
2. Wire or plate, wrought
3. Wire, pure gold, solder built up.
4. Combinations of the above.

1. Class 1 - D & I.R. X (2D)
2. " 2 - D & I.R. - (2D)
3. " 3 - D.R. - (2D)
4. " 4 - D.R. Δ Δ (3+D)

1. Recessed
2. Surface, including, Partial, Full
and Multiple occlusal rests and
pads, and rests for occlusal cone

1. Direct retainers and Occlusal
rests completed, checked for
interference, and in mouth.

2. Impression
Preferably Muscle-trimmed

3. Cast

1. All plaster
2. Plaster, sectional method.
3. Plaster and compound, sectional method.
4. Dr. Furness' Method.

1. Stone, with wax reliefs for undercut
parts, Indirect assembly.
2. Investment, Material for
direct assembly.

4. Assembly
(with all metal parts joined by solder)
(Determine sequence in insertion;
one, two or three directions)

1. Indirect, off cast
2. Direct, on cast (with loss of cast)

5. Checking above in mouth
(spot grinding if necessary)

1. Vulcanite with temporary
wax base
2. Metal, as to be finished.

6. Anterior Teeth :- applied Esthetics

7. Posterior Teeth :- Articulation and
Occlusion

8. Checking in mouth, in wax mount.

9. Finishing.

2. CONSTRUCTION (PRECISION)

3. INSERTION OR INSTALLATION

1. Before piece snaps "home" Carbon paper and spot-grinding.

2. After piece snaps "home" (final
allocation of load) Carbon paper and spot-grinding.

Teach patient and have patient
practice insertion and removal
before leaving

3. Subsequent Adjustment and
Rebasings at subsequent sittings,
fill load is properly distributed.

4. MAINTENANCE

(The Patients
Part)

1. General Oral Health :- Diet, exercise, Elimination, Immunity, etc.

2. Saliva Flush & Cleansing 5 times per day.

3. Removal night

4. Notification

5. Repairs (a) fractures & simple replacements
(b) Additions for teeth lost
(c) Other repairs

6. Literature for patients covering above.

Figure No. 9. Chart on Partial Denture Service as shown. Note four stages, with detail as subsequently described.

PRACTICE OF PARTIAL DENTURE SERVICE.

33. SUBJECT MATTER, GENERAL.

The practice of partial denture service consists of:—

- (a) Examination of the semi-edentulous patient for discovery of the details which have bearing on the case.
- (b) The notation of the injuries consequent on extraction to be prevented or avoided.
- (c) The most favorable juxtaposition of standardized parts with which to accomplish this purpose.

After the preliminary examination, follows the practical application of the theory previously acquired to the special condition found in the mouth of the semi-edentulous patient. This detail may be best redistributed in an engineering sequence as follows:—

- (a) Design.
 - (b) Construction.
 - (c) Installation or insertion.
 - (d) Maintenance and repair.
- (d) The subsequent phases of construction, installation, and maintenance, in which details of prevention constantly recur.

34. PRELIMINARY EXAMINATION.

This may be done in part, or, if consultation with specialist difficult or impossible, in whole by the attending Dentist. A suggested sequence for which follows:—

History.

1. Questioning of patient as to any pathological condition outside of mouth; if apparently present reference to physician for examination.

Objective Symptoms.

2. General Dental examination for all Dental disease, which may or may not give rise to systemic disease as above, with or without radiographs. If obscure, preferably by expert dental diagnostician.

Subjective Symptoms.

3. Particular dental examination, and consultation with, and treatment from, if necessary.
 - (a) Preventologist:—Various items as elimination of predisposition to dental disease, etc. No restoration may be begun with any assurance of success while predisposition to dental disease exists in the mouth.

- (b) Peridontist:—Various items, as probable condition of pericementum under stress, relief from overload, disposition of stresses, etc.
- (c) Orthodontist:—Various items, as preference of orthodontic treatment over prosthetic, combined orthodontic and prosthetic treatment, inclusion of orthodontic appliances as retainers in prosthetic appliances, etc.
- (d) Oral Surgeon:—Various items, as preference of surgical treatment over prosthetic, combined surgical and prosthetic treatment, etc.
- (e) Exodontist:—Character of mucosa support which will probably follow extraction and possible alveolectomy to improve these. Indications of alveolectomy with prosthetic restorations for esthetics, etc.
- (f) Any or all of above.

In all cases certain preliminaries, as charts, models, etc., may be necessary, previous to special examination for prosthetic work. Here follows a list indicating the use or non-use of these:—

- 1. None—Simple cases evident on inspection.
- 2. Charts only—Simple cases not evident on inspection.
- 3. Charts and study models—More difficult cases not evident on inspection, with marked variations from normal of condition and position of teeth not readily noted on charts. (Variations on a horizontal plane only).
- 4. Upper and lower study models—Ditto with marked variations of position of teeth between upper and lower jaws. (Variations on a vertical and horizontal plane).
- 5. Upper and lower study models mounted on articulator from bite blocks—ditto when sufficient facets are not present for securing the occlusal position.

Here follows a special dental examination for denture design and specification (after Prothero) in which various items are noted for further use in design and specifications, construction, installation, and maintenance.

- 1. Number and location of remaining teeth and spaces. Note these on chart, step No. 1, design.
- 2. Condition of remaining teeth.
- 3. Condition of mouth and mucous membrane.
- 4. Condition of alveolar border, extent of absorption, location of muscular attachments and frena.
- 5. Condition, location and extent, hard and soft areas.
- 6. Relation of upper and lower ridge.
- 7. Condition of saliva.

35. DESIGN AND ITS DEFINITION.

A design of a partial restoration is a:

- (a) Mental picture, or,
- (b) Mento-graphic supplemented by drawing of the proposed restoration which should be, as far as possible completed before any material is collected or work begun.

The mental process in design involves:

- (a) A mental store house of the pictures of the standardized parts from which all partial dentures may be constructed, acquired from theoretical studies, as already noted.
- (b) A knowledge as to their correct use i.e. greatest functional efficiency and least destructive tendency upon natural teeth also acquired from the theoretical studies.
- (c) Examination for discovery of conditions peculiar to case,
- (d) A simple working procedure in securing above mentioned mental or graphic pictures, suitable for case in hand.

36. STEPS IN DESIGN.

The writer's hypothesis (2¹⁶ check) is that Dentists and students may best learn to design all partial dentures above a certain grade of difficulty by a graphic method, (involving the use of a rubber stamp (C. W. Mack & Co., 42 Adelaide West, \$2.50, or printed chart of fourteen teeth) in *four definite and distinct steps* in which the above mentioned preventive considerations continually recur in redistributed order.

1. Saddles.
2. (0) Parts connecting saddles.
3. (4) Direct and indirect retention and connectors. (At this stage the case is classified).
4. (3) Occlusal rests if indicated (this order subject to variations).

For simple cases both charts and models may be omitted. While in complex cases especially those in which the bite must be lengthened, both charts, study models articulated and the presence of the patients are sometimes required in order to develop a design.

37. SADDLES DESIGN.

Allocation of Load to Mucosa.

In the design of saddles, the mucosa is given its share of the load. The softer the mucosa the larger should be the saddle. A slightly intermittent pressure is more favorable, and a steady pressure in excess compresses the circulation, causes a so-called "strangulation" with absorption similar to too great peripheral valve seal on full dentures.

In outline the saddles should be kept away from the gingival

margin. With regard to saddle-area, Dr. Chaye's statement of "saddles area must equal combined pericemental areas of teeth missing and supplied" probably approaches close to the solution (Items of interest, November, 1915). Professional knowledgs regarding this fundamental exists almost entirely from professional experience, more or less definite. Until research on proper loading of mucosa, proper loading of the teeth and correlation of saddles and tooth movement is done, parial dentures will continue to wreck teeth. In the opinion of the writer the subject is so lacking in accurate data that a series of factors to be weighed in the choice of support (mucosa, root, or combination is all that is available). Fig. 12. Below follows steps in saddle design:

Upper and Lower.

1. Buccal periphery, posterior, to be carried to peripheral valve seal.
2. Buccal and labial periphery, anterior, as above unless no artificial gum is desired.
3. About teeth 1—2mm space to avoid capillarity.
4. Lingual periphery as determined by area of mucosa support desired and in the next step. (Parts connecting saddles).

38. PARTS CONNECTING SADDLES.

These (when required) are almost always located to the lingual of the teeth, occasionally buccal and labial, and may be developed as below.

Upper and Lower.

1. If alternate space and tooth or similar use continuous construction.
2. If alternate space and group of teeth ,or similar, use skeleton construction.

Upper.

3. If parts required to cross anterior, flat or semi-round, cast or wrought, and placed in a suitable depression between rugae. If this not possible, flat wide piece.
4. If parts required to cross posterior, between first and second molar, cast or wrough, flat or semi-round, depending upon grade, and compensated for differences between hard and soft areas.
- 4a. Choice between anterior, posterior, or both. This depending on strength of appliance required, range, available space, occupation and choice of patient, and other factors.

If Soft Mucosa, Upper.

5. All saddles should be extended to cover mucosa on working side of fulcrum line over entire vault.

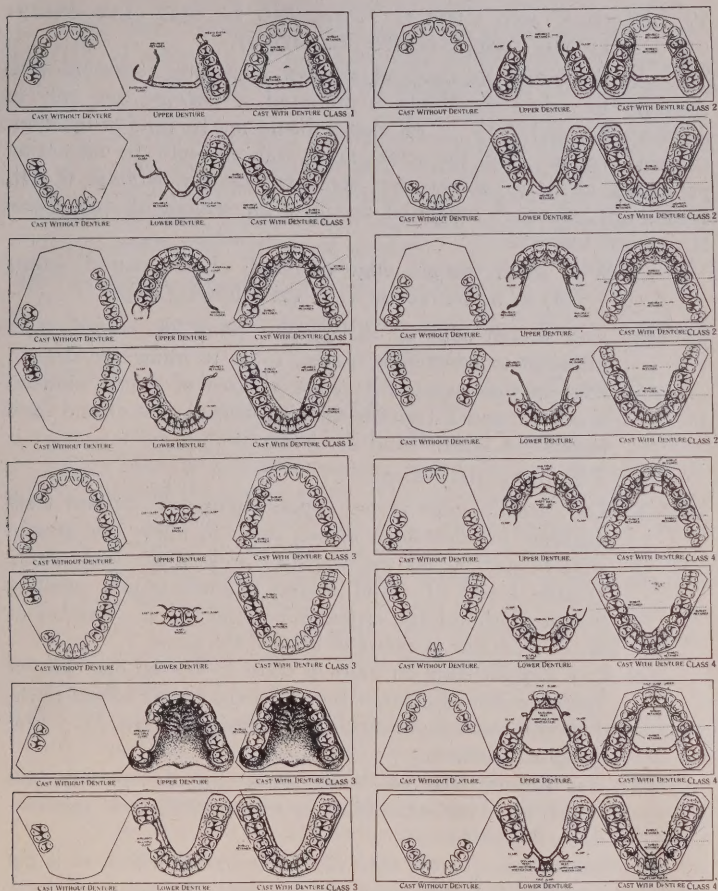


Figure No. 10. In step No. 3 in design the case becomes classified. Representative cases (with inversion) of each of the four classes.

1. Class one cases with direct retainers diagonally opposite, direct and indirect retention.
2. Class two cases with direct retainers diametrically opposite, direct and indirect retention.
3. Class three cases with direct retention on one side, direct retention only.
4. Class four cases with three or more direct retainers in a semi-triangular, or semi-quadrilateral relationship, direct retention only.

Lower.

6. All parts connecting lower saddles, lingual bar, low as muscle attachment will permit, and one or two mm. lingual from soft tissues.

39. POSITION AND CHOICE, RETAINING DEVICES (AT WHICH STEP THE CASE BECOMES CLASSIFIED).

Under this head the clasp of smallest dimension consistent with efficiency to reduce capillarity is preferred, if possible two only in number (classes 1-2-3). Cast clasps should not be used in locations causing torques. And the writer notes with pleasure the increasing popularity of clasps of narrower contacts from the writings of Dr. Roach and others. A suggested detail for the positioning and choice of retainers follows:

1. With small straight edge to hand, choose paired (class 1-2-3) or triplet, (class 4) in the following steps.

- (a) Lay straight edge across opposite pairs of natural teeth adjacent to edentulous spaces, so as to allow the straight edge to pass across the centre of area of figures outlined in steps 1 and 2 (usually omitting central, lateral and third molars). Classes 1 and 2.

This being inexpedient:

- (b) Lay straight edge across opposite pairs of natural teeth adjacent to edentulous spaces, so as to allow the straight edge to pass across the centre of area of the entire arch, (classes 1 and 2). Add indirect retainers usually omitting the use of central and lateral upper and lower. This brings the fulcrum line in centre of area of the piece.
- (c) Lay straight edge on pairs of teeth in line on one side of figure developed in steps 1 and 2, which may afford retention, with or without auxilliary adhesion, (class 3). This being inexpedient;
- (d) Lay straight edge on three teeth, (or if necessary four teeth) in a semi-triangular or semi-quadrilateral relationship. (Class 4).
2. Select from (1) the most favorable paired group, or if not possible, (2) the triplet or quadruplicate group of teeth most suitable for clasps.
- (a) Teeth with decided opposing convexities, (M.D.-B.L.-L.I. X 2).
- (b) Teeth of good pericemental and enamel condition.
- (c) Teeth with freedom from caries, erosion, abrasion, large fillings, inlays, etc.
- (d) Teeth remote as possible from the anterior mouth.

- (e) Teeth with other indications for clasps as not mentioned above.
- 3. This being in whole or in part impossible, choose, (as above) compound retainers, especially in teeth, either requiring, or with readily removable large inlays, crowns or similar:
 - (a) Non precision if saddle supported at one end only.
 - (b) Precision if (if grade of work admits and if saddles supported at both ends) or non-precision, *chiefly* removable bridges.
- 4. In classes 1 and 2 add indirect retainers, if necessary, (contact or carrying stress of mastication) as in figure No. 5, upon suitable teeth omitting upper and lower, centrals and laterals. These indirect retainers to be directly opposite unretained portions of saddles.

40. SUPPLEMENTARY NOTES ON CLASPS.

- 1. All clasps must touch the enamel only. This is of greatest importance for preventive reasons.
- 2. *Independent Movement of Clasp and Saddle and "Slip."*

In addition to a sufficiently firm grasp of the anchor tooth, a clasp should be sufficiently resilient to allow a "slip" or a slight movement of the clasp up and down and round the anchor tooth. This movement allows the saddle or the anchor tooth to move independently in a limited degree of the saddle, minimizing torque and overload (provided the mucosa is not of soft texture), in which a non-rigid connector is needed, as already noted. This represents approximately a universal joint in which an independent movement is possible within small limitation.

- 3. *Choice of Cast, wrought, or Composite Clasps.*

A large percentage of losses of anchor teeth from torque, are due to the use of cast clasps, possible too wide and too thick, lacking in resiliency, and corresponding "slip," and retaining a free saddle, (a saddle directly retained at one end only) resting in turn upon soft mucosa. This is the most frequent example of the main contra-indication of the cast clasp, viz: "Cast clasps must not be used in any instance which, because of relative non-resiliency, and consequent lack of slip they may subject an anchor tooth to vertical or horizontal torques from free saddles on mucosa of any degree of compressibility."

Cast clasps find a special use in short spaces with suitable teeth for clasps at each end of space, in which wrought clasps are contra-indicated because of danger of swallowing.

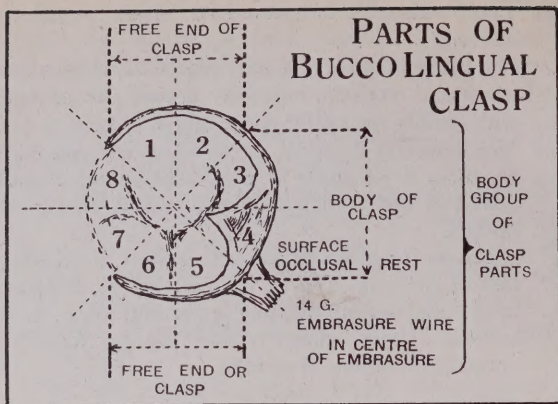


Figure No. 11. **Parts of a bucco-lingual clasps.** The arrangement varies in other types to a certain extent. Note the clasp ordinarily encircles 6-8 or $\frac{3}{4}$ the circumference of the tooth. Parts of clasp as above noted. Note position of 14 gauge connector in embrasure.

Under the latter circumstances, the wrought (preferably) wire band or composite clasp is indicated, which ordinarily possesses sufficient slip and elasticity to accommodate this difference or movement, and with in extreme cases non-rigid connectors.

Notes on Design of Individual Clasps.

All clasps consist of:

- (a) Two resilient and contoured free ends or their equivalent, equidistant above and below line of widest cross section.
- (b) A body connecting the free ends which is more or less resilient. The proper position of the contoured free ends is that of conformation to the contours of the pair of opposing convex surfaces, as chosen, resulting in a positive grip, assisted by tenso-friction, *not more than sufficient to hold the restoration to place.*

Body must be (a) below leaning tooth surfaces; (b) narrow especially at right angles to fulcrum line.

41. CONNECTORS.

These may be of 14 gauge wire placed in the embrasure except in cases in which extreme disproportion exists between the movements of the saddle and anchor tooth, or for other reasons. In such cases non-rigid connectors may be used, as Giffen, Nicholls, Weinstein, Dresch, or similar. See Figures 2-7-8.

42. POSITION AND CHOICE OF OCCLUSAL RESTS.

(Allocation of load to the teeth and their pericementa. Load must be applied to teeth coincident with their long axes only.)

At this stage the occlusal rests, (if their use is thought desirable) may be drawn in, which allocates a load to the teeth. This is also an unexplored field, and in the judgment of the writer is best taught by factors indicating root support as attached, (Fig. 12) governed by the general principles, that saddles resting on soft mucosa tend to

PARTIAL DENTURE SERVICE

Chart #4

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FACTOR CHART

For the purpose of assisting in the determination of support, (steps "1's 1, 2 & 4) Design, Chart #3.

1. SOME FACTORS INDICATING MUCOSA SUPPORT :-

Larger saddle areas with stress of mastication carried primarily by saddles and subjacent mucosa, and without occlusal rests are indicated in proportion to :-

- (a) Larger distances on each side of remaining teeth.
- (b) Smaller amount of pericementum available for support.
- (c) Less favorable condition of pericementum of teeth available, or not available for support.
- (d) Less firm condition of the mucosa.
- (e) Pressure from the antagonizing teeth above the average.

2. SOME FACTORS INDICATING ROOT SUPPORT :-

Smaller saddles with stress of mastication carried primarily by the teeth and their pericementa; and with occlusal rests, are indicated in proportion to :-

- (a) Smaller distance between the remaining teeth.
- (b) Larger amount of pericementum of teeth available for support.
- (c) More favorable condition of pericementum of teeth available for support.
- (d) More firm condition of the mucosa.
- (e) Pressure from antagonizing teeth below the average

3. SOME FACTORS INDICATING COMBINATION SUPPORT :-

with stress of mastication divided between roots and mucosa, with saddles of medium area and with occlusal rests.

- (a) Practically the remainder of the 2¹⁶ cases.

(P.S. The above hypothetical and subject to checking with 2¹⁶ combinations)

BRENNAN

Figure No. 12. Factor Sheet. From the above, in proportion to the factors above, and present in the proposed restoration, is the type support chosen—

- (a) Root.
- (b) Mucosa.
- (c) Combination support of both root and mucosa.

throw bulk of the stress on the teeth, and also that teeth of diminished or diseased pericementum should not be given this duty. Some writers on this subject condemn this principle, thus eliminating the allocation of the load for the tissues designed by nature for the purpose; the dental pericementum—in which the writer is unable to wholly concur.

In many cases the sequelae following non-occlusion may be prevented with large occlusal rests. Capillarity in these may be minimized by keeping the gold out of contact with the deep sulci.

A sequence for the development of these follows:

1. Determine support of piece; see factor chart Fig. 12.
2. Sketching in occlusal rests.
 - (a) If mucosa support no occlusal rest.
 - (b) If root support entirely (removable bridges) occlusal rests, Figure 2, with or without saddles.
 - (c) If mucosa and root support with *ample space* for occlusal rest: quarter, half, full, or multiple occlusal pads as required to close space.
 - (d) If both mucosa and root support with *small space* for occlusal rest; buccal or lingual entry surface occlusal rest: M.D., B.L., or L.I., rigid loops; recessed occlusal rests. Remove small amount of enamel from marginal ridges of upper and lower teeth involved, if absolutely unavoidable, and without approaching the dentine.

Note.—Usually all teeth adjacent to spaces must share support.

Note.—All M.D. clasps and B.L. and L.A. clasps considerably covering occlusal cone of tooth attached act as occlusal rests.

Note.—Upon all uncut cone-shaped teeth (e.g., cuspids) either M.D.—B.L.—or L. 1 rigid 2-3 loops are indicated.

43. CONSTRUCTION.

Maintenance of accuracy is the chief difficulty in construction and much research in stresses and strains in bent and cast metal to avoid distortion is necessary. A shrunken casting or distorted framework exerts a permanent stress on anchor teeth which must result in ruin. Interference in anatomical articulation may be checked by intelligent use of adjustable articulators and the Wadsworth attachment is recommended with sulcus angles of natural and artificial teeth to be identical. Escapes provided on occlusal surface tend to reduce overload. In Figure 6 a series of items in construction may be noted, details of which would fill an essay of considerable size.

44. INSERTION OR INSTALLATION.

Too much stress cannot be laid on the necessity for proper adjustment at this stage, both before, immediately after, and for a short time

subsequent; and during the initial stages of the practical use of the appliance. At this stage the final and accurate distribution of stresses on teeth, mucosa, or both, is done, and to a large extent the life history of the remaining teeth is determined. The operation may be conducted entirely by the use of thin wax, carbon paper, and spot-grinding.

45. MAINTENANCE AND REPAIR. (presupposing healthy oral conditions).

Preventive items (in part). (The dentist's part.)

- (1) Settling clasps and saddles, gingival impingement, etc., correction.
- (2) Correction of impingement hard area or elsewhere.
- (3) Watching for overload from occlusal rest with no rebasing in expected absorptions (especially after recent extraction); and for various overloads not correctly anticipated in saddle and occlusal rest designs.

Oral Health Conditions. (The patient's part.)

- (a) Cleansing five times per day.
- (b) Saliva flush.
- (c) Removal at night.
- (d) Use of notification slips for periodic examination to be furnished by Dentist.
- (e) Report for repairs, rebases, etc., if necessary.

The first three items of personal hygiene, as above, may be given direct appeal, with reference to the parallel of maintenance of all kinds. Prophylactic notification system is equal with partial denture notification systems in the opportunity for prevention, as injuries which may result from broken clasp, occlusal rest or similar, cannot be foretold with accuracy.

46. CONCLUSION.

Realizing with concern the lack of professional knowledge of the subject of partial restorations, and, to a certain extent, the lack of real interest in the subject, the writer offers the following suggestions in conclusion.

1. Research of partial denture problems to be included in as many research programs as possible. From probably few causes are more teeth lost than at present from lack of this knowledge. Here follows a few suggested details:

(a) Design.

1. Checking hypothesis of design and classifications with 2¹⁶ or more cases.

2. Study of proper distribution of stresses of all kinds on teeth, mucosa, or combination support.
3. Clasp design to minimize capillarity and other disadvantageous factors.

(b) Construction.

1. Simple and standardized impression technique.
2. Elimination of warpage and distortion by similar standardized instruction.

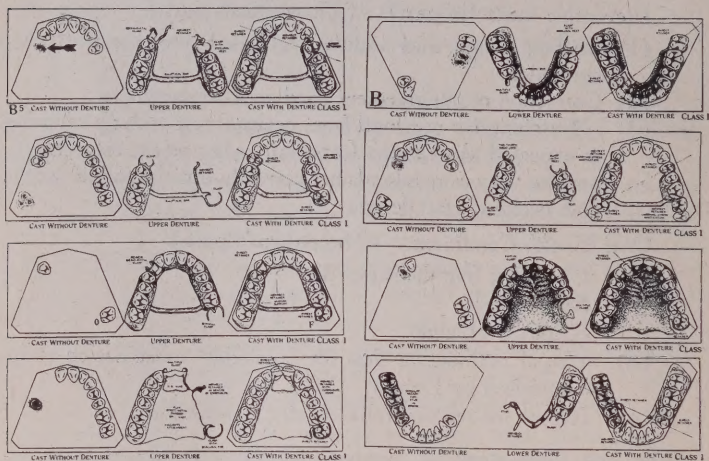


Figure No. 13. A group of class 1 cases.

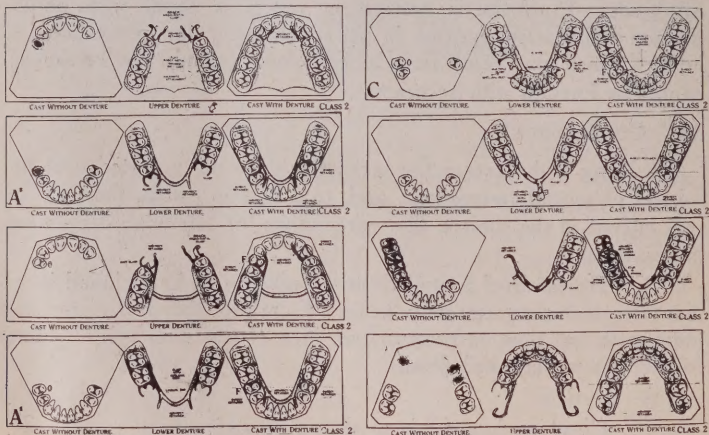


Figure No. 14. A group of class 2 cases.

3. *Reduction of cost and improvement of production methods.*
- (c) *Installation, Maintenance, etc.*

1. Periodic records of selected cases checking efficiency of designs in present use.

Also every support to proposed Partial Denture Society to be formed by the "National Dental Society Association" this summer at Los Angeles (1922).

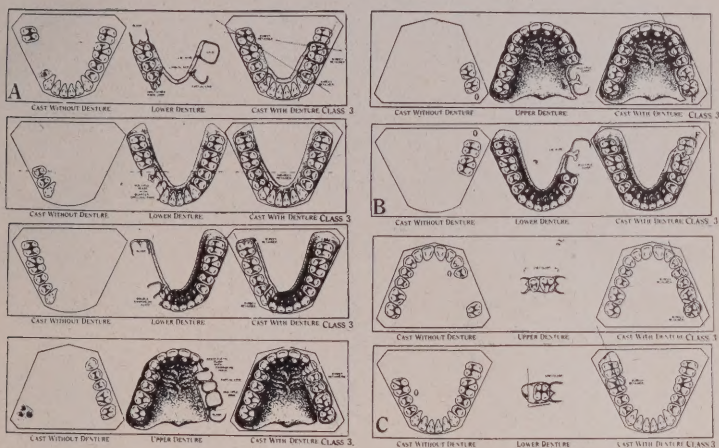


Figure No. 15. A group of class 3 cases.

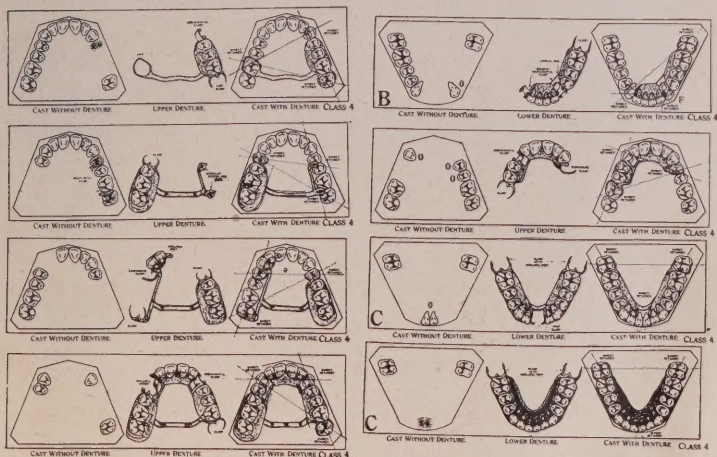


Figure No. 16. A group of class 4 cases.

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Combinations as an Aid in the Discovery of Fundamentals in Dentistry and Other Sciences

W. E. CUMMER, D.D.S.

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1

Combinations as an Aid in the Discovery of Fundamentals in Dentistry and Other Sciences

W. E. CUMMER, D.D.S.

ROYAL COLLEGE OF DENTAL SURGEONS OF ONTARIO.

Revised by Professor G. R. Anderson, Prof. of Applied Physics, Royal College of Dental Surgeons of Ontario, and the Engineering Faculty, University of Toronto; and Robert J. Reade, M.A., M.D., D.D.S., Toronto.

FOREWORD.

THE following monograph is of peculiar value to the investigator, and to the teacher. It enables the investigator to ascertain the extent of the work in which he is about to engage, as well as to comprehend the possible relationship of the various phenomena that come under his notice. To the teacher it is useful, and necessary, because it helps him to plan a course of instruction in which every detail of his subject will be mechanically presented to his mind, and no point overlooked.

The Author has displayed much ingenuity in compiling the tables presented in the following work. He has given much time and care to make clear to the careful reader the subject matter of his treatise, even at the expense of being charged with repeated explanations. All the Master Charts are constructed on the same principle, so that a thorough understanding of one of them, makes easy the comprehension of the rest.

Because it is so important to grasp the principle of a Master Chart, a word of explanation at the outset will make more simple the perusal of the brochure.

There are 8 Master Charts given in the text, Figures 2, 3, 4, 5, 8, 10, 16, 17.

The first requirement of the reader, in order to readily grasp the subject, is an insight into the end to be served by the use of the Master Charts. The object sought and attained in their structure is very simple and practical, and applicable to all sciences. In general, then, the endeavor of the author, is to enable the investigator to have all the facts known in the case under consideration, presented in every pos-

sible combination, for the purpose of studying and comparing the phenomena in their various relationships. By this means, the danger of overlooking any possible connection between the observed facts is eliminated.

To illustrate in the Science of Dentistry, take an example from the text, namely, the consideration of the upper four anterior teeth. Every possible combination of these teeth, from four absent to four present is given in Master Chart 2¹ (Fig. 7). By this means the instructor in the school is able to prepare models, and to teach the student the means of dealing with the treatment of every possible case that can be met with in practice.

Again, in the case of a certain disease, suppose there are four antecedents, or possible causes. There is the possibility of the disease being caused by all four antecedents acting together; or by any three together; or by any two together; or separately by any one of the four; or possibly by none of them. Now by substituting A.B.C.D. respectively for the four antecedents, the table gives every combination possible, no possible combination is overlooked. By this means the probability of reaching a correct conclusion is enhanced.

From the foregoing it will be quite evident why there are a number of Master Charts, namely, 2¹, 2², 2³, 2⁴, 2⁵, etc. There is only one consideration that might present a difficulty in the understanding of this presentation at the first reading, and that has a very simple explanation. It will be noticed that the Charts are, as above, 2¹, 2², 2³, 2⁴, etc. That is they are all two, raised to some power. What does 2 mean? Simply this, that in every Chart only two conditions are considered, that is the condition of being PRESENT, or the condition of being ABSENT. As in the foregoing example, one, two, three or four teeth are either present, or absent, in the various cases considered. When this idea of the integer 2 is grasped the problem presents little difficulty.

The rest is quite clear. The indices ¹, ², ³, ⁴, etc., over the integer 2 simply tell how many teeth, or causes, or things are being considered. 2¹ means we are considering one tooth present or absent; 2² two teeth, one or both present or absent; 2³ three teeth, one, two or three teeth present or absent; 2⁴ four teeth, one, two, three or four teeth present or absent, and so on.

The above considerations will render the reading of the Master Chart an easy matter, and enable the investigator beneficially to apply the Charts to the particular subject under examination.

The accurate information afforded by the Charts has a wide field of application in the various sciences. The student has compiled for him the various combinations, without the necessity of making the calculations, and is thus helped to avoid errors due to oversight. He has presented to him in definite and accurate form the extent of his work, and the complications with which he will be confronted.

ROBERT J. READE.

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PART I.—GENERAL.

1. SCIENCE AND ITS MUTABILITY.

In view of the vast store of related, semi-related and apparently closely related facts in the sciences, the lay mind is somewhat surprised to learn that in Science to-day there are but few universally accepted truths. Scarcely a decade passes, but a fact, or combination of facts, discovered either by accident, or by research, will shake to its foundations a theory, conceded by generations of scientists, and regarded as almost unassailable. Such discoveries will place the hypothesis, or theory, in an entirely new relation with facts. One of the most recent examples of this is the modification of the molecular theory by the discovery of the nature of radium. In Dentistry, a comparatively young science, change after change occurs in the explanation of conditions which underlie the various types of dental diseases. As an example of this there may be noted the various hypotheses proposed seeking to express the etiology of pericemental disease. Some of these hypotheses have been in vogue within the memory of comparatively young practitioners.

2. SCIENTIFIC TRUTH AND ITS CHARACTER.

Fixed and immutable truths, other than such supernatural truths as have been revealed to man, appear to exist in mathematics only. As an example of mathematical truth, it would be difficult to conceive that two and two made other than four; or as an example of scientific truth, so called, it would be difficult not to accept Newton's conception of gravity, which has withstood the test of examination of scientific minds for upwards of three hundred years. A belief or subscription to a truth, scientific or otherwise, is, in its truest sense, an unbiassed mental contemplation of such truth. This mental attitude is a gift that belongs only to those who examine phenomena without any desire to make conditions comply with any personal or preconceived hypothesis. True scientists, therefore, are those who observe and compare for the sake of truth itself.

3. SCIENTIFIC TRUTH AND ITS DEVELOPMENT.*

We gain our facts from observation and experiment. From an arduous and open-minded examination of a large number of correlated facts the observer forms an hypothesis. The hypothesis is serviceable to afford a solution, more or less probable, of a problem not definitely solved. Even though the hypothesis has been tested by a multiplicity of facts, perhaps not observable during the lifetime of him who suggested the hypothesis, but covering periods, even centuries, of scientific thought, it may at last by a positive proof become established and accepted as a scientific truth. Such is the history of New-

*Sections 1, 2, 3 revised by Rev. John E. Burke, Toronto.

ton's laws of gravity; and in a lesser sense of many of the hypotheses of Dentistry, as Millers hypothesis of the Etiology of Caries of the teeth, and Black's hypothesis of "Extension for Prevention."

4. MATHEMATICAL COMBINATIONS AS AN AID IN THE DEVELOPMENT OF SCIENTIFIC TRUTH IN CERTAIN PHASES OF DENTISTRY.

The examination of a large number of instances is essential for the framing of the working hypothesis. A larger number of instances may either confirm or disprove the hypothesis. Any means which will develop facts and bring them to our attention is therefore of practical value. The cases which are observable by a dentist, even during a lifetime of practice, are necessarily limited, and repetitions often occur. These cases, together with the experiences of other dentists, and brought under the application of mathematical combinations, showing *ALL* the possible combinations, result in a fairly complete mass of data upon which an investigation may be based.

5. MATHEMATICAL COMBINATIONS AND THEIR CHARACTER.

In Algebra there is a section known as "Permutations and Combinations." Combinations treats of the different combinations which may be found in any number of persons, places or things. For example, if Nature bestowed upon man only one tooth, instead of sixteen, only two combinations (2^1) could obtain, namely, tooth present and tooth absent. Similarly, if Nature bestowed upon man two teeth, instead of sixteen, four (2^2) combinations would result, which would be as follows (naming one tooth A, and the other tooth B, for the sake of convenience.)

First Combination, A B.

Second Combination, A.

Third Combination, B.

Fourth Combination, None.

This is, one combination of two teeth, two combinations of one tooth, and one combination of no teeth, or four combinations in all. *Permutations*, which treats of a change of *position* of the teeth or other objects under consideration, has no place in this article.

6. SCIENTIFIC TRUTH IN MATHEMATICAL COMBINATIONS.

From the foregoing example of four (2^2) combinations of two teeth, it may be noted that mathematical truth exists;—for just as certainly as two and two make four, is the fact that two teeth may be found in (2^2) or four combinations, no more, no less. This holds good in all combinations, no matter how great their magnitude; and whatever combinations may be used in an investigation, such as for example, that of the standardization of loading,* retention, impressions, and

*This is the Plimssoll mark of Prosthetic Dentistry. There are two tissues and a combination of these which support the load of mastication as received by prosthetic appliances, namely:—The teeth and their periodontia; the mucosa; and a combination of these.

similar investigations in Denture Service, there immediately becomes identified with that investigation the quality of mathematical certainty.

7. PLAN IN THIS ARTICLE TO FACILITATE THE USE OF COMBINATIONS IN RESEARCH PROBLEMS.

Hereinafter will be found tables which will be called Master Charts of the various combinations possible in one object 2^1 or two; in two objects 2^2 or four; in three objects 2^3 or eight; in four objects 2^4 or sixteen; in five objects 2^5 or thirty-two; in six objects 2^6 or sixty-four; in seven objects 2^7 or one hundred and twenty-eight; in eight objects 2^8 or two hundred and fifty-six.

It will be noted that the tables increase in size according to the number of objects considered.

The Master Charts of the entire series (2^1 - 2^2 - 2^3 - 2^4 - 2^5 - 2^6 - 2^7 - 2^8 ; Figures 2-3-4-5-8-10-16-17) at the outset may be explained here. Let us examine the structure of a Master Chart in general. As all the Master Charts are constructed alike, this explanation will apply to all of them, and may be referred to at all times. For an example let us examine the structure of Master Chart 2^5 .

MASTER CHART OF 2^5 COMBINATIONS = 32 COMBINATIONS				GROUP	
ROYAL COLLEGE OF DENTAL SURGEONS				FIVES	Section 5
				FOURS	Section 4
				THREES	Section 3
1 A B • C D E	9 A • C D E	17 B • C D E	25 • C D E		
2 A B • C D	10 A • C D	18 B • C D	26 • C D		
3 A B • D E	11 A • D E	19 B • D E	27 • D E	TWOS	Section 2
4 A B • C E	12 A • C E	20 B • C E	28 • C E		
5 A B • C	13 A • C	21 B • C	29 • C		
6 A B • D	14 A • D	22 B • D	30 • D	ONES	Section 1
7 A B • E	15 A • E	23 B • E	31 • E		
8 A B •	16 A •	24 B •	32 •	NONES	Section 0
				TOTAL COMBINATIONS	32

Fig. 1.
MASTER CHART 2^5 .

In this Chart there are six sections, formed by horizontal and oblique lines for the sake of convenience and symmetry. The numbers to the left of each combination (1-2-3-4-5 up to 32) simply indicate each combination. That is, for example, in section three there are ten combinations, namely, 5-6-7-10-11-12-18-19-20 and 25.

This is a Master Chart of the Combinations of five persons, places, or things, and section 5, No. 1, contains the only one possible group of *five* taken together. Section 4 (Nos. 2-3-4-9- and 17) contains all the possible groups of any *four* of the five taken together.

Section 3 (Nos. 5-6-7-10-11-12-18-19-20- and 25) contains all the possible groups of any *three* of the five taken together.

Section 2 (Nos. 8-13-14-15-21-22-23-26-27 and 28) contains all the possible groups of any *two* of the five taken together.

Section 7 (Nos. 16-24-29-30- and 31) contains all the possible groups of any *one* of the five taken together.

Section 0 (No. 32) contains only *one* possible groups of *none* taken together.

Note.—A summary of the number of combinations in each section here follows.

Sec. 5.....	1 Combination.
Sec. 4.....	5 Combinations.
Sec. 3.....	10 Combinations.
Sec. 2.....	10 Combinations.
Sec. 1.....	5 Combinations.
Sec. 0.....	1 Combination.

Note also the symmetry in the increase and decrease of the number of combinations. This will be found to obtain in all of the Charts.

COMBINATIONS OF ONES $2^1 = 2$		
GROUPS		
1	A	ONES
2		NONES
TOTAL COMBINATIONS 2		

Fig. 2
MASTER CHART 2¹

COMBINATIONS OF TWOS $2^2 = 4$			
GROUPS			
1	A	B	TWOS
2	A		ONES
3		B	
4			NONES
TOTAL COMBINATIONS 4			

Fig. 3
MASTER CHART 2²

COMBINATIONS OF THREES $2^3 = 8$				
GROUPS				
1	A	B	C	THREES
2	A	B		TWOS
3		B	C	
4	A		C	ONES
5	A			
6		B		NONES
7			C	
8				NONES
TOTAL COMBINATIONS 8				

Fig. 4
MASTER CHART 2³

COMBINATIONS OF FOURS $2^4 = 16$					
GROUPS					
1	A	B	C	D	FOURS
2	A	B	C		THREES
3		B	C	D	
4	A		C	D	TWOS
5	A	B		D	
6	A	B			ONES
7		B	C		
8			C	D	NONES
9	A			D	
10	A		C		NONES
11		B		D	
12	A				NONES
13		B			
14			C		NONES
15				D	
16					NONES
TOTAL COMBINATIONS 16					

Fig. 5
MASTER CHART 2⁴

The foregoing Master Charts, (Figs. 2-3-4-5) are combinations of one, two, three, and four objects, respectively 2^1 , 2^2 , 2^3 , 2^4 , or 2, 4, 8, and 16 Combinations. Note that in Charts 2^1 (Fig. 2), 2^2 (Fig. 3), 2^3 (Fig. 4), 2^4 (Fig. 5), the sections are formed by horizontal lines only, on account of the small number of combinations.

In these Master Charts, as well as in all others, the letters of the alphabet are used to represent things under consideration. It will be noted that the combinations are arranged in various groups. Thus in Fig. 2, which represents the combinations of one object, there are two combinations in all (2^1), namely:—

One group of ones, (1, Sec. 1, Fig. 2.)

One group of nones, (2, Sec. 0, Fig. 2.)

Also in Fig. 3, which represents the combinations of two objects, there are four combinations in all (2^2), namely:—

One group of twos, (1, Sec. 2, Fig. 3.)

One group of ones, (2-3, Sec. 1, Fig. 3.)

One group of nones, (4, Sec. 0, Fig. 3.)

Likewise in Fig. 4, which represents the combinations of three objects, there are sixteen combinations in all (2^3), namely:—

One group of fours, (1, Sec. 4, Fig. 5.)

One group of threes, (2-3-4-5, Sec. 3, Fig. 5.)

One group of twos, (6-7-8-9-10-11, Sec. 2, Fig. 5.)

One group of ones, (12-13-14-15, Sec. 1, Fig. 5.)

One group of nones, (16, Sec. 0, Fig. 5.)

*While it is fairly easy to write down all the combinations of a small number of factors, without danger of missing any, the case is different when the number is large. A word as to the method of calculation may therefore be in order. If there are N factors and two conditions P and A, then the number of combinations is the sum of the coefficients in the expansion $(P+A)^N$. From the binomial theorem these coefficients are known to be N, $\frac{N(N-1)}{1 \cdot 2}$, $\frac{N(N-1)(N-2)}{1 \cdot 2 \cdot 3}$, etc., and the sum of these is the total number of combinations. For example, take the case where N is 5; we have $(P+A)^5$, the coefficients of which are $1+5+10+10+5+1$, so that there are

1 Combination of 5 Present 0 Absent					
5	"	" 4	"	1	"
10	"	" 3	"	2	"
10	"	" 2	"	3	"
5	"	" 1	"	4	"
1	"	" 0	"	5	"

And the total number is 32.

*Prof. G. R. Anderson, R.C.D.S., Toronto.

PART II.—DEALING WITH MASTER CHART 2³.

8. AN EXAMPLE OF THE USE OF THE 2³ TABLE OF COMBINATIONS, MASTER CHART, FIG. 4.

In every Chart the integer (which is 2) indicates that two conditions operate, which are:—

First condition: Present.

Second condition: Absent.

And the index (or the small figure set above the integer) indicates the number of times the integer is multiplied by itself. For example, 2³ equals $2 \times 2 \times 2 = 8$, the total number of possible combinations of three objects. In this Fig 4, three things are represented, as indicated by the index. For an example in Fig. 6, take the three typical arch forms (square, tapering, ovoid) of Dr. Leon Williams:—the index represents these three forms, while the integer represents (1) the presence or (2) the absence of none, one, two, or three of the arch forms.

The complete table of 2³, or eight, will then appear as follows, the letter A representing the square type, the letter B, the tapering type, and the letter C, the ovoid type:—

One group of threes.

1. A, B, C, Square,—tapering,—Ovoid, (not found in Nature.)

Three groups of twos.

2. A, B, Square, tapering, only in patient.
3. B, C, Tapering, ovoid, only in patient.
4. A, C, Square, ovoid, only in patient.

Three groups of ones.

5. A, square, only in patient.
6. B, Tapering, only in patient.
7. C, Ovoid, only in patient.

One group of none.

8. None (Not found in Nature).

Total Combinations 8 (2³).

In this table Dr. Nelson has excluded the one combination of threes, and the one combination of none, as not being found in Nature, the remainder being the combinations as found in Nature which is noted in Figure 6.

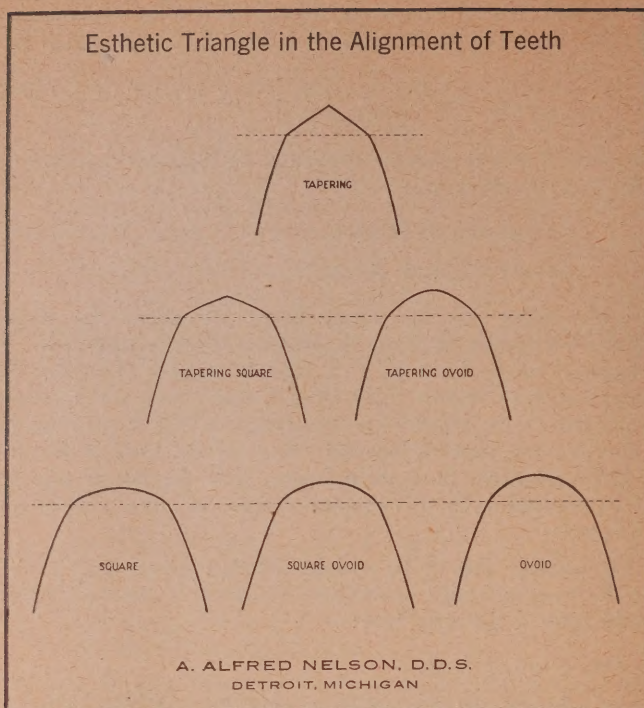


Figure No. 6. Dr. Nelson's scheme of the Primary Arch Forms and their Binary Combinations as noted in the Text Sec. 8.

9. OTHER TABLES OF 2^3 OF INTEREST TO DENTISTS.

Another applications of this table may be noted in the estimate of the two factors of present and absent in the partnership of three dentists to provide for future eventualities.

In this instance the integer of 2^3 represents one condition of present, or in partnership, and the other condition of absent, or out of partnership. The index of 2^3 represents the dentist and his two partners. The table will then be as follows, substituting A, B, and C, as below.

Dentist A, Partner, B, Partner, C.

One group of threes.

1. Dentist, A, Partner, B, Partner, C, All in partnership.

Three groups of twos.

2. Dentist, A, Partner B, Only in partnership.
3. Partner, B, Partner, C, Only in partnership.
4. Dentist, A, Partner, C, Only in partnership.

Three groups of ones.

5. Dentist, A, only in partnership.
6. Partner, B, only in partnership.
7. Partner, C, only in partnership.

One group of none.

8. None, in partnership.

Total Combinations 8 (2^3).

A further application. Many dentists have devoted themselves to the study of political economy. This same 2^3 table is of interest in the case of three by-elections, in which the political party has a candidate, in each district. The conditions are, (1) present, or elected and (2) absent or defeated. Substitute as above and we have the following combinations:

One group of threes.

1. Candidate, A, Candidate, B, Candidate C, All returned.

Three groups of twos.

2. Candidate, A, Candidate, B, Only returned.
3. Candidate B, Candidate C, Only returned.
4. Candidate, A, Candidate, C, Only returned.

Three groups of ones.

5. Candidate, A, Only returned.
6. Candidate, B, Only returned.
7. Candidate, C, Only returned.

One group of none.

8. None returned.

Total Combinations 8 (2^3).

With four arch forms, with four partners, or with four candidates, the combinations would total 16, or 2^4 ; with five arch forms, with five partners, or with five candidates, the combinations would total 32, or 2^5 ; with six arch forms, with six partners, or with six candidates, the combinations would total 64 or 2^6 . With ascending numbers there is the same progression. By a simple process of substitution, using the 2^4 , 2^5 , 2^6 , Master Charts as found in text, Figures 5, 8A, 10, respectively, the detailed combinations may be readily found.

PART III.—DEALING WITH MASTER CHART 2^4 .

10. EXAMPLES OF THE USE OF A 2^4 TABLE OF COMBINATIONS IN PROSTHETIC DENTISTRY.

For the study of the design of Bridges for the four anterior teeth, the total combinations (in number 16 or 2^4) may be noted in plan and labial elevation. See Fig. 7.

It may readily be seen that the study of all the combinations of the four teeth in such a table, would afford an investigator considerable assistance in the formation of hypotheses regarding design, etc.

In this work the dental tables consider teeth only as present in their *normal* situation, or absent.

PLAN OF		ALL COMBINATIONS OF FOURS $2^4=16$						ROYAL COLLEGE OF DENTAL SURGEONS
								PATIENT'S ANTERIOR SIDE
1		5		9		13		
2		6		10		14		
3		7		11		15		
4		8		12		16		

Figure No. 7A. Combinations of Upper four teeth shown in Plan.

ELEVATION OF		ALL COMBINATIONS OF FOURS — $2^4 = 16$ —						ROYAL COLLEGE OF DENTAL SURGEONS
								PATIENT'S ANTERIOR SIDE
1		5		9		13		
2		6		10		14		
3		7		11		15		
4		8		12		16		

Figure No. 7B. In this Chart only the Combinations of the Upper Anterior four teeth are shown in Elevation; the remaining teeth are shown in situ only to complete the picture.

ELEVATION OF		ALL COMBINATIONS OF FOURS— $2^4 = 16$ —						ROYAL COLLEGE OF DENTAL SURGEONS
								PATIENT'S ANTERIOR SIDE
1		5		9		13		
2		6		10		14		
3		7		11		15		
4		8		12		16		

Figure No. 7C. In this Chart only the Combinations of the Lower Anterior four teeth are shown; the remaining Upper and Lower teeth are shown in situ only to complete the picture.

Combinations of the Anterior four teeth. Figures 7A and 7B Upper, and Figure No. 7C Lower, both in plan and elevation.

This figure is of value in the formation of hypotheses of principles of design. It tends towards standardization, and simplification of each problem, by bringing to the attention of the observer all of the possible combinations of these teeth, thus serving as an aid for study and research.

11. ANOTHER EXAMPLE OF A 2^4 TABLE IN PROSTHETIC DENTISTRY.

This combination is also of value in the study of the temperamental system of physico-facial characteristics, in the choice of a suitable hue of teeth in edentulous cases. The combinations of the four primary types, namely, A, Sanguineous, B, Bilious, C, Nervous, D, Lymphatic, corresponding approximately to, creamy yellow, bronze yellow, pearl gray, and pallid, respectively, may be built into a 2^4 table; the integer 2 represents, (1) the presence, or (2) absence of the particular temperament in the patient; and the index figure 4 represents the four temperaments. The total combination of 2^4 or 16 may be noted below, using Master Charts 2^4 , figure 5, and substituting the various temperaments for the letters, A-B-C-D.

Example of Combinations of Temperaments.

One group of fours.

1. Sanguineous, Bilious, Nervous, Lymphatic, all present in patient.

Four groups of threes.

2. Sanguineous, Bilious, Nervous, only present in patient.
3. Bilious, Nervous, Lymphatic, only present in patient.
4. Sanguineous, Nervous, Lymphatic, only present in patient.
5. Sanguineous, Bilious, Lymphatic, only present in patient.

Six Groups of twos.

6. Sanguineous, Bilious, only present in patient.
7. Bilious, Nervous, only present in patient.
8. Nervous, Lymphatic, only present in patient.
9. Sanguineous, Lymphatic, only present in patient.
10. Sanguineous, Nervous, only present in patient.
11. Bilious, Lymphatic, only present in patient.

Four groups of ones.

12. Sanguineous, only present in patient.
13. Bilious, only present in patient.
14. Nervous, only present in patient.
15. Lymphatic, only present in patient.

One group of nones.

16. None, present in patient.

Total Combinations 16 (2^4).

Of these, the six binaries, (groups of twos,) and the four singles (groups of ones,) are of practical use as an aid in choice of hue in edentulous patients.

12. COMBINATIONS OF FOUR PERICEMENTAL DISEASES AS NAMED BY DR. BOX.

A disease of the Peridontium, included in periclasia, has been, in part, designated by Harold K. Box, D.D.S., Ph.D., of the Royal College of Dental Surgeons of Ontario, as a "Chronic Suppurative Periodontitis Complex", consisting of four definite histo-pathological phases as follows:

1. Rarefying Osteitis Non-infective.
2. Chronic Suppurative Gingivitis.
3. Chronic Suppurative Pericementitis.
4. Infective Rarefying Osteitis.

A study of these in their various combinations would result as follows:—substituting the letters in figure 5, for the diseases as named above.

One group of fours.

1. A-B-C-D:—Rarefying Osteitis Non-infective; Chronic Suppurative Gingivitis; Chronic Suppurative Pericementitis; Infective Rarefying Osteitis; all affecting the tooth.

Four groups of threes.

2. A-B-C:—Rarefying Osteitis Non-infective; Chronic Suppurative Gingivitis; Chronic Suppurative Pericementitis; affecting the tooth.
3. B-C-D:—Chronic Suppurative Gingivitis; Chronic Suppurative Pericementitis; Infective Rarefying Osteitis; affecting the tooth. Dr. Box designates this combination as "Chronic Peridontitis Simplex."
4. A-C-D:—Rarefying Osteitis Non-infective; Chronic Suppurative Pericementitis; Infective Rarefying Osteitis; not found.
5. A-B-D:—Rarefying Osteitis Non-infective; Chronic Suppurative Gingivitis; Infective Rarefying Osteitis; rarely, if ever, found.

Six groups of twos.

6. A-B:—Rarefying Osteitis Non-infective; Chronic Suppurative Gingivitis; affecting the tooth.
7. B-C:—Chronic Suppurative Gingivitis; Chronic Suppurative Pericementitis; affecting the tooth.
8. C-D:—Chronic Suppurative Pericementitis; Infective Rarefying Osteitis; not found.

9. A-D:—Rarefying Osteitis Non-infective; Infective Rarefying Osteitis; not found.
10. A-C:—Rarefying Osteitis Non-infective; Chronic Suppurative Pericementitis; not found.
11. B-D:—Chronic Suppurative Gingivitis; Infective Rarefying Osteitis; rarely, if ever, found.

Four groups of ones.

12. A:—Rarefying Osteitis Non-infective; only affecting the tooth.
13. B:—Chronic Suppurative Gingivitis; affecting the tooth.
14. C:—Chronic Suppurative Pericementitis; affecting the tooth; not found.
15. D:—Infective Rarefying Osteitis; affecting the tooth.

One group of nones.

16. None; affecting the tooth.

Of the above, Dr. Box states that Nos. 4-8-9-10 and 14 are not found in Nature: the rest are of use in the study of this disease.

13. 2⁴ TABLES CONCERNING NON-TECHNICAL MATTERS OF INTEREST TO THE DENTIST.

In the place of four anterior teeth, and of the four temperaments, many other persons, places, or things, may be substituted for the letters A-B-C-D, in figure 5. For example, a dentist, who has wife, son, daughter, and mother, is desirous of making a will, and considering the various contingencies that may arise; or again, this 2⁴ table would be an aid to an attorney in advising a client as to the number of different provisions he should make, with regard to the presence (alive) or absence (dead) of each legatee. The table 2⁴ or 16 possible combinations appear below, substituting A-B-C-D as in previous examples:—

One group of fours.

- 1 A-B-C-D:—Mother, Wife, Son, Daughter. All alive.

Four groups of threes.

2. A-B-C:—Mother, Wife, Son. Only alive.
3. B-C-D:—Wife, Son, Daughter. Only alive.
4. A-C-D:—Mother, Son, Daughter. Only alive.
5. A-B-D:—Mother, Wife, Daughter. Only alive.

Six groups of twos.

6. A-B:—Mother, Wife. Only alive.
7. B-C:—Wife, Son. Only alive.
8. C-D:—Son, Daughter. Only alive.
9. A-D:—Mother, Daughter. Only alive.

10. A-C:—Mother, Son. Only alive.
 11. B-D:—Wife, Daughter. Only alive.

Four groups of ones.

12. A:—Mother. Only alive.
 13. B:—Wife. Only alive.
 14. C:—Son. Only alive.
 15. D:—Daughter. Only alive.

One group of nones.

16. None. All dead.

Total Combinations 16 (2^4).

Of course it will be noted that different tables may be employed for the particular number of beneficiaries to be considered. For example in the case of three people, 2^3 Master Chart would be used; in the case of five people, 2^5 Master Chart would be used; and so on, the particular table being used for the particular number desired.

PART IV.—DEALING WITH MASTER CHART 2^5 .

14. MASTER CHART 2^5 WITH 32 COMBINATIONS, AND ITS CONSTRUCTION.

The structure of this 2^5 Chart is of interest. It is made up of Master Charts 2^2 and 2^3 , Figs. 8B and 8C. The dot (.) which divides the Combinations has no significance, but is only for purposes of explanation as in the present case.

MASTER CHART OF 2^5 COMBINATIONS = 32 COMBINATIONS				GROUP	
ROYAL COLLEGE OF DENTAL SURGEONS				FIVES	Section 5
				FOURS	Section 4
				THREES	Section 3
1 A B • C D E	9 A • C D E	17 B • C D E	25 • C D E		
2 A B • C D	10 A • C D	18 B • C D	26 • C D		
3 A B • D E	11 A • D E	19 B • D E	27 • D E	TWOS	Section 2
4 A B • C E	12 A • C E	20 B • C E	28 • C E		
5 A B • C	13 A • C	21 B • C	29 • C		
6 A B • D	14 A • D	22 B • D	30 • D	ONES	Section 1
7 A B • E	15 A • E	23 B • E	31 • E		
8 A B •	16 A •	24 B •	32 •	NONES	Section 0
				TOTAL COMBINATIONS	32

Figure 8A.

On examining the first eight Combinations (1—8) of the Chart, it will be noticed that the part of the Combination on the left side of the dot is made up of AB, which is repeated eight times. Turning to Chart 2^2 , Fig. 8B, it is found that AB is the first group of that chart (later the second, third, and fourth groups are noted). Again examine the first 8 Combinations of the 2^5 Chart, but on the right hand of the

dot, and substitute the letters A B C for the letters C D E. Now on the right of the dot will be found the first eight, or all the Combinations of Chart 2^3 . So it is seen that the first eight groups of the 2^5 Chart is made up of group one, AB of the 2^2 Chart (eight times) in juxtaposition with groups one, two, three, four, five, six, seven, and eight of the 2^3 Chart.

COMBINATIONS OF TWOS $2^2 = 4$				
				GROUPS
1	A	B	TWOS	Section 2
2	A		ONES	Section 1
3		B		
4			NONES	Section 0
TOTAL COMBINATIONS				4

Figure 8B.

COMBINATIONS OF THREES $2^3 = 8$						
				GROUPS		
1	A	B	C	THREES	Section 3	
2	A	B		TWOS	Section 2	
3		B	C			
4	A		C			
5	A					
6		B		ONES	Section 1	
7			C	NONES	Section 0	
8						
TOTAL COMBINATIONS				8		

Figure 8C.

The component groups of the Master Chart 2^5 (Fig. 8A) are fully described in section 7. In the following text, section 14, an analysis of the chart is given showing how the chart 2^5 , Fig. 8A, is made up of charts 2^2 , Fig. 8B, and 2^3 Fig. 8C.

Again on examining the second eight Combinations (9-16) of Chart 2^5 , it will be noticed that the part of the combination on the left of the dot is made up of A, which is repeated eight times. Turning to Chart 2^2 , it will be found that A is the second group of that chart, (later the third and fourth groups are noted.) Again examine the second eight combinations of the 2^5 Chart on the right of the dot, and once more substitute the letters A B C for the letters D E F. Now on the right of the dot will be found the first eight, or all the Combinations of 2^3 Chart. So it will be seen that the second eight groups (9-16) of the 2^5 Chart is made up of group two (A) of the 2^2 Chart (repeated eight times) in juxtaposition with group one, two, three, four, five, six, seven, eight of the 2^3 Chart.

Once again on examining the third eight combinations (17-24) of Chart 2^5 it will be noted that the part of the combination on the left of the dot is made up of B which is repeated eight times. Turning to Chart 2^2 it will be found that B is the third group of that Chart (later the fourth group will be noted). Again examine the third eight Combinations of the 2^5 Chart on the right of the dot, and once more substitute the letters A B C for the letters D E F. Now on the right of the dot will be found the first eight, or all the Combinations of 2^3

Chart. So it will be seen that the third eight groups (17-24) of 2^5 Chart is made up of group three (B) of the 2^2 Chart (repeated eight times) in juxtaposition with groups one, two, three, four, five, six, seven, and eight of the 2^3 Chart.

Finally, examining the fourth eight combinations (25-32) of Chart 2^5 it will be noted that the part of the Combinations on the left of the dot is made up of nothing, which is repeated eight times. Turning to Chart 2^2 it will be found that nothing or nones is the fourth group of that Chart. (Now all the groups of Chart 2^2 have been accounted for.) Again examine the fourth eight Combinations of Chart 2^5 on the right of the dot, and once more substitute the letters A B C for the letters D E F. Now on the right of the dot will be found the first eight or all the combinations of the 2^3 Chart. So it will be seen that the fourth eight groups (25-34) of the 2^5 Chart is made up of four (nones) of the 2^2 Chart (repeated eight times) in juxtaposition with groups one, two, three, four, five, six, seven, and eight of the 2^3 Chart.

This analysis of higher powers of tables into lower powers of tables, or as it may be stated from another point of view the synthesis of lower powers of tables to form higher powers of tables will be found in all Master Charts shown in this article, and is summarized in Fig. 32.

15. A 2^5 CHART OF INTEREST IN DENTISTRY.

				FIVES		SECTION No. 5
				FOURS		SECTION No. 4
1 M O D B L	9 M D B L	17 O D B L	25 D B L	THREES		SECTION No. 3
2 M O D B	10 M D B	18 O D B	26 D B	TWOS		SECTION No. 2
3 M O B L	11 M B L	19 O B L	27 B L			
4 M O D L	12 M D L	20 O D L	28 D L	ONES		SECTION No. 1
5 M O D	13 M D	21 O D	29 D			
6 M O B	14 M B	22 O B	30 B			
7 M O L	15 M L	23 O L	31 L	NONES		SECTION No. 0
8 M O	16 M	24 O	32			

Figure No. 9. A Chart of juxtaposition of the five surfaces of a tooth. Mesial, Occlusal, Distal, Buccal, and Lingual. This Chart is made by substituting the letters A-B-C-D, and E, in Master Chart Fig. 8A with the letters M-O-B-D-L, representing the five simple surfaces. Note one group of fives (section 5); five groups of fours (section 4); ten groups of threes (section three); five groups of twos (section two); five groups of ones (section one); one group of nones (section 0).

Figure 9 is an interesting Chart of the relationship possible between the five surfaces of a tooth for the study of the larger cavity preparations, or for any other purpose for which a complete list of the juxtapositions of the surfaces may be desired. The complete list is as follows, as drawn from Master Chart in Figure 8A:—

One group of fives.

Mesial- Occlusal- Distal- Buccal- Lingual.

Five groups of fours.

Mesial- Occlusal- Distal- Buccal.

Mesial- Occlusal- Buccal- Lingual.

Mesial- Occlusal- Distal- Lingual.

Mesial- Distal- Buccal- Lingual.

Occlusal- Distal- Buccal- Lingual.

Ten groups of threes.

Mesial- Occlusal- Distal.

Mesial- Occlusal- Buccal.

Mesial- Occlusal- Lingual.

Mesial- Distal- Buccal.

Mesial- Buccal- Lingual.

Mesial- Distal- Lingual.

Occlusal- Distal- Buccal.

Occlusal- Buccal- Lingual.

Occlusal- Distal- Lingual.

Distal- Buccal- Lingual.

Ten groups of twos.

Mesial- Occlusal.

Mesial- Distal.

Mesial- Buccal.

Mesial- Lingual.

Occlusal- Distal.

Occlusal- Buccal.

Occlusal- Lingual.

Distal- Buccal.

Buccal- Lingual.

Distal- Lingual.

Five groups of ones.

Mesial.

Occlusal.

Distal.

Buccal.

Lingual.

One group of none.

None.

It may be noted that the above Combinations are merely juxtapositions of surfaces. Should a list of compound cavities or preparations be desired, two eliminations will be required, which a dentist will readily comprehend,—viz.:—Mesial- Distal and Buccal- Lingual.

PART V.—DEALING WITH MASTER CHART 26

16. A MASTER CHART FOR 2^6 WITH 64 COMBINATIONS.

MASTER CHART OF 2 ⁵ COMBINATIONS = 64 COMBINATIONS						ROYAL COLLEGE OF DENTAL SURGEONS						GROUP															
												SIZES															
1	A	B	C	D	E	F	9	A	B	C	D	E	F	17	B	C	D	E	F	25	A	C	D	E	F	FIVES	Section 6B
2	A	B	C	D	E		10	A	B	C	D	E		18	B	C	D	E		26	A	C	D	E		FIVES	Section 5B
3	A	B	C	D	E	F	11	A	B	C	D	E	F	19	B	C	D	E	F	27	A	C	D	E	F	FOURS	Section 4B
4	A	B	C	D	E		12	A	B	C	D	E		20	B	C	D	E		28	A	C	D	E			
5	A	B	C	D	E	F	13	A	B	C	D	E	F	21	B	C	D	E	F	29	A	C	D	E	F		
6	A	B	C	D	E		14	A	B	C	D	E		22	B	C	D	E		30	A	C	D	E		THREES	Section 3B
7	A	B	C	D	E	F	15	A	B	C	D	E	F	23	B	C	D	E	F	31	A	C	D	E	F		
8	A	B	C	D	E		16	A	B	C	D	E		24	B	C	D	E		32	A	C	D	E		TWOS	Section 2B
														FOURS	Section 4A												
33	A	C	D	E	F		41	B	C	D	E	F	49	C	D	E	F	67	D	E	F	THREES	Section 3A				
34	A	C	D	E			42	B	C	D	E		50	C	D	E		68	D	E							
35	A	C	D	E	F		43	B	C	D	E	F	51	C	D	E	F	69	D	E	F	TWOS	Section 2A				
36	A	C	D	E			44	B	C	D	E		52	C	D	E		80	D	E							
37	A	C	D	E	F		45	B	C	D	E	F	53	C	D	E	F	81	D	E	F						
38	A	C	D	E			46	B	C	D	E		54	C	D	E		82	D	E		ONES	Section 1A				
39	A	C	D	E	F		47	B	C	D	E	F	55	C	D	E	F	83	D	E	F						
40	A	C	D	E			48	B	C	D	E		56	C	D	E		84	D	E		NONES	Section 0A				
														TOTAL COMBINATIONS	64												

Fig. 10.

MASTER CHART 2^d

COMBINATIONS OF THREES $2^3 = 8$					
				GROUPS	
1	A	B	C	THREES	Section 3
2	A	B		TWOS	
3		B	C		Section 2
4	A		C		
5	A			ONES	Section 1
6		B			
7			C		
8				NONES	Section 0
TOTAL COMBINATIONS					8

Fig. 10 A

MASTER CHART 23.

Master Chart of 2⁸ Combinations. The upper half of the Chart Fig. 10 includes combinations, from 1 to 32; the lower half includes combinations from 33 to 64. Groups of fours, threes, and twos, will be found in both upper and lower sections of the drawing.

There are two parts, only because of limited space across the page; they should be read as side by side. In the following text, section sixteen, an analysis of this chart is given, showing how the Chart 2⁶ Figure 10 is made up of two 2³ Master Charts, Fig. 10A.

This Master Chart of 2^6 (Fig. 10) is one of the most useful in this series. It shows a juxtaposition of 2^3 Combinations on either side of

the dot, similar to that described in paragraph 14. Use the letters A-B-C, D-E-F being substituted for A-B-C in Figure 4.*

Now in this chart (Fig. 10A), the first combination of 2^3 , namely A-B-C, is repeated eight times on the left hand side of the dot in Figure 10. It will also be noted that the second Combination, A-B, and the third Combination, B-C, and the following combinations in Fig. 10A are repeated eight times in Fig. 10 on the left hand side of the dot.

Now on the right hand side of the dot we have D-E-F (which has been substituted for A-B-C,) in juxtaposition, first with A-B-C eight

PLAN COMBINATIONS OF SIXES - 2 ⁶ = 64 - ROYAL COLLEGE OF DENTAL SURGEONS										PATIENT'S RIGHT SIDE
		SAME PROBLEM AS No								
1		17		1	33		49			
2		18		2	34		50			
3		19		3	35		51			
4		20		4	36		52			
5		21		5	37		53			
6		22		6	38		54			
7		23		7	39		55			
8		24		8	40		56			
				SAME PROBLEM AS No.						
9		25		9	41		57			
10		26		10	42		58			
11		27		11	43		59			
12		28		12	44		60			
13		29		13	45		61			
14		30		14	46		62			
15		31		15	47		63			
16		32		16	48		64			

Figure No. 11A. Plan Upper.

times, next with A-B eight times, and with the following combinations of Fig. 10A as described in the paragraph immediately preceding.

This process is continued to the final group of combinations, Nos. 57 to 64, at which the last combination of 2^3 , which is none, is repeated eight times in juxtaposition with the eight combinations of 2^3 . See the concise analysis of Master Chart 2^5 , section 14.

*For the sake of reference, Fig. 4 is repeated above Fig. in 10A.

17. 2⁶ CHARTS ARE OF PRACTICAL VALUE IN DENTAL RESEARCH

At the present time one of the unsolved problems of Partial Denture Design is that of the development of simple working formulae which

ELEVATION OF ALL COMBINATIONS OF SIXES - $2^6 = 64$ -						ROYAL COLLEGE OF DENTAL SURGEONS	
						PATIENT'S RIGHT SIDE	
1		17		33		49	
2		18		34		50	
3		19		35		51	
4		20		36		52	
5		21		37		53	
6		22		38		54	
7		23		39		55	
8		24		40		56	
9		25		41		57	
10		26		42		58	
11		27		43		59	
12		28		44		60	
13		29		45		61	
14		30		46		62	
15		31		47		63	
16		32		48		64	

Figure No. 11B. Elevation Upper.

PLAN AND ELEVATION OF ALL COMBINATIONS OF THE POSTERIOR SIX TEETH, UPPER RIGHT SIDE.

This has been developed from the 2⁶ Master Chart, Fig. 10, and shows 64 Combinations. Note in the elevation (Fig. 11B) the central and lateral are sketched in, only to complete the picture, but in the plan (Figure 11A) they are not shown. In this Chart, the letters of the Master Chart, Fig. 10, are substituted with teeth: A, being the third molar; B, the second molar; C, the first molar; D, the second bicuspid; E, the first bicuspid, and F, the cuspid. This method is adopted in the use of all Master Charts.

may be readily used by dentists to decide in Partial Restorations whether to give the load:—

- Wholly to the mucosa.
- Wholly to the remaining teeth, or
- Divide the load between the two.

At the present time investigators differ considerably on this subject, and it is largely with the hope of stimulating an interest, and drawing

forth comment on this subject, that the writer has been led to undertake the preparation of this article.

As a general proposition the anterior four teeth, as teeth suitable to support a very considerable load in mastication, may be eliminated. One very apparent reason is that their function is to cut food and not masticate it. This leaves the Posterior six teeth on either side to consider. Charts of the upper and lower Posterior six teeth, their plan (view of occlusal surface) and elevation are here given, Figures 11-12.

PLAN COMBINATIONS OF SIXES — $2^6 = 64$ —						ROYAL COLLEGE OF DENTAL SURGEONS	
SAME PROBLEM AS No.			PATIENT'S RIGHT SIDE				
1		17		33		49	
2		18		34		50	
3		19		35		51	
4		20		36		52	
5		21		37		53	
6		22		38		54	
7		23		39		55	
8		24		40		56	
9		25		41		57	
10		26		42		58	
11		27		43		59	
12		28		44		60	
13		29		45		61	
14		30		46		62	
15		31		47		63	
16		32		48		64	

Figure No. 12A. Plan Lower.

18. THE USE OF GROUPS OF COMBINATIONS IN ANY OF THE MASTER CHARTS OF THIS SERIES.

The writer had occasion, in developing a summary for students in possible methods of taking of the bite, to ascertain all the combinations of the following six conditions:

1. Full Upper Denture.
2. Full Lower Denture.
3. Partial Upper Denture.

4. Partial Lower Denture.
5. Natural Upper Denture.
6. Natural Lower Denture.

This includes six different conditions, which may or may not be present in the mouth, but two of which only can be present in the mouth at the same time. There are six things to be considered in this

ROYAL COLLEGE OF DENTAL SURGEONS					
ELEVATION ALL COMBINATIONS OF SIXES - $2^6 = 64$ - PATIENT'S RIGHT SIDE LOWER					
1		17		33	
2		18		34	
3		19		35	
4		20		36	
5		21		37	
6		22		38	
7		23		39	
8		24		40	
9		25		41	
10		26		42	
11		27		43	
12		28		44	
13		29		45	
14		30		46	
15		31		47	
16		32		48	
				49	
				50	
				51	
				52	
				53	
				54	
				55	
				56	
				57	
				58	
				59	
				60	
				61	
				62	
				63	
				64	

Figure No. 12B. Elevation Lower.

PLAN AND ELEVATION OF ALL COMBINATIONS OF THE POSTERIOR SIX TEETH LOWER RIGHT SIDE.

This has been developed from 2⁶ Master Chart, Fig. 10, and shows 64 combinations. Note in the elevation (Fig. 12B) the central and lateral are sketched in, only to complete the picture, but in the plan (Fig. 12A) they are not shown. In this Chart the letters of the Master Chart, Fig. 10, are substituted with teeth, A, being the third molar; B, the second molar; C, the first molar; D, the second bicuspid; E, the first bicuspid, and F, the cuspid.

case, taken two at a time. The groups, taken two at a time, will be found in section 2B (upper half) and 2A (lower half), Master Chart 2⁶.*

*For reference this chart is repeated, figure 14A. It will also be remembered that, because of lack of space, the chart is printed in two sections, upper section (B) and lower section (A) and the groups of twos are located in each section.

 PLAN COMBINATIONS OF SIXES — $2^6 = 64$ ROYAL COLLEGE OF DENTAL SURGEONS PATIENT'S ANTERIOR SIDE							
1		17		33		49	
2		18		34		50	
3		19		35		51	
4		20		36		52	
5		21		37		53	
6		22		38		54	
7		23		39		55	
8		24		40		56	
9		25		41		57	
10		26		42		58	
11		27		43		59	
12		28		44		60	
13		29		45		61	
14		30		46		62	
15		31		47		63	
16		32		48		64	

Figure No. 13.

Plan of Combinations of the anterior Upper Six Teeth, useful in the study of anterior restorations either fixed or removable, and also in the discovery of principles of Design and Construction. Teeth are here substituted for letters of the Master Chart as in figures 11 and 12.

MASTER CHART OF 2 ⁶ COMBINATIONS = 64 COMBINATIONS				ROYAL COLLEGE OF DENTAL SURGEONS				GROUP
⑥								SIXES
1 A B C * D E F	9 A B * D E F	17 B C * D E F	25 A C * D E F	FIVES				Section 6B
2 A B C * D E	10 A B * D E	18 B C * D E	26 A C * D E	Section 5B				
3 A B C * E F	11 A B * E F	19 B C * E F	27 A C * E F	FOURS				Section 4B
4 A B C * D F	12 A B * D F	20 B C * D F	28 A C * D F	Section 3B				
5 A B C * D	13 A B * D	21 B C * D	29 A C * D	THREES				Section 2B
6 A B C * E	14 A B * E	22 B C * E	30 A C * E	Section 4A				
7 A B C * F	15 A B * F	23 B C * F	31 A C * F	Section 3A				
8 A B C *	16 A B *	24 B C *	32 A C *	TWOS				
				FOURS				Section 2A
33 A * D E F	41 B * D E F	49 C * D E F	57 * D E F	THREES				Section 1A
34 A * D E	42 B * D E	50 C * D E	58 * D E	Section 0A				
35 A * E F	43 B * E F	51 C * E F	59 * E F	TWOS				
36 A * D F	44 B * D F	52 C * D F	60 * D F	Section 1A				
37 A * D	45 B * D	53 C * D	61 * D	ONES				
38 A * E	46 B * E	54 C * E	62 * E	Section 0A				
39 A * F	47 B * F	55 C * F	63 * F	NONES				
40 A *	48 B *	56 C *	64 *	TOTAL COMBINATIONS 64				

Figure 14 A.

MASTER CHART OF 2 ⁶ COMBINATIONS = 64 COMBINATIONS				ROYAL COLLEGE OF DENTAL SURGEONS				GROUP	
⑥									
</									

In the foregoing diagram the numerals 16, 24, 32, etc., indicate the different combinations as seen in the Master Chart, referring to combinations of twos.

Upper Half.

16, A B

24, B C

32, A C

Lower Half.

37, A D

45, B D

53, C D

58, D E

38, A E

46, B E

54, C E

59, E F

39, A F

47, B F

55, C F

60, D F

Substituting the letters A-B-C-D-E and F, for the six different conditions as follows:—

A—Full Upper

B—Full Lower.

C—Partial Upper.

D—Partial Lower.

E—Natural Upper.

F—Natural Lower.

This gives us the following possible juxtapositions, nine* in all:—

1. A-B—Full Upper and Lower.
2. B-C—Full Lower and Partial Upper.
3. A-C—Full Upper—Partial Upper. (Not found in Nature.)
4. A-D—Full Upper—Partial Lower.
5. A-E—Full Upper—Natural Upper. (Not found in Nature.)
6. A-F—Full Upper—Natural Lower.
7. B-D—Full Lower—Partial Lower. (Not found in Nature.)
8. B-E—Full Lower—Natural Upper.
9. B-F—Full Lower—Natural Lower. (Not found in Nature.)
10. C-D—Partial Upper—Partial Lower.
11. C-E—Partial Upper—Natural Upper. (Not found in Nature.)
12. C-F—Partial Upper—Natural Lower.
13. D-E—Partial Lower—Natural Upper.
14. E-F—Natural Upper—Natural Lower.
15. D-F—Partial Lower—Natural Lower. (Not found in Nature.)

From the above it will be seen the use of the Master Chart in getting all the possible combinations of the six Dentures referred to, without possibility of error, and with little mental effort.

*There are fifteen juxtapositions, but six of these are impossible.

GROUP COMBINATIONS OF SIXES - 2 ⁶ = 64 - PATIENT'S RIGHT SIDE ROYAL COLLEGE OF DENTAL SURGEONS							
SIXES X 1	FIVES X 6	FOURS X 15	THREES X 20	TWOS X 15	ONES X 6	NONES X 1	
1	2	7	8	39	40	64	
	3	6	51	38	61		
	4	12	13	47	58		
	17	20	57	59	63		
	25	5	29	37	62		
	9	10	52	54	48		
		11	22	24			
		19	30	46			
		18	34	16			
		27	15	45			
		28	31	55			
		26	50	60			
		33	21	53			
		49	35	32			
		41	14	58			
			36				
			44				
			43				
			42				
			23				

Figure 15.

A redistribution of the combinations shown in plan Fig. 11, section A. This is merely a rearrangement in groups of sixes, fives, fours, threes, twos, ones, and nones, with the hope of discovering a simple formula for a proper loading of teeth in Partial Denture Design; in other words, the discovery of the use, or non-use, of occlusal rests or similar fixtures which transmit the stresses of mastication to the teeth and their pericementa. In the opinion of the writer, the proper redistribution of these 64 Combinations into groups governed by simple rules as to the use, or non-use, of occlusal rests, will go far in solving the problem. It must be kept in mind, however, that, no matter how simple, or exact such a formula may be, that it is always subject to the biological factor, the vital conditions of the bone, pericementum, etc., upon which these structures rest.

19. REDISTRIBUTION OF 2⁶ COMBINATIONS AS A POSSIBLE AID TO THE DEVELOPMENT OF SIMPLE FORMULAE IN LOADING IN PARTIAL DENTURE DESIGN.

In Partial Dentures, the redistribution, into classes, of any of the combinations of teeth, will be of material assistance in obtaining a simple formula in such a consideration as the loading problem. Any classification in dentistry is an effort to redistribute cases into classes. Each class is governed by more or less simple rules, or treated by more or less similar methods, thus standardizing and simplifying dental problems for the average practitioner. For the purpose of redistribution in such charts as figures 11-12-13, each numbered section may be cut with the shears following the lines and cross lines, and rearranged on a soft wood board by pins, in such groups as may be seen fit, by such as may care to use these charts for such purposes of investigation. An example of this may be noted in figure 15.

PART VI.—DEALING WITH MASTER CHART 27.

20. A MASTER CHART OF 2^7 WITH 128 COMBINATIONS.

[illegible]

Fig. 16.

Master Chart of 2^4 , 128 Combinations in all. This Chart is built up of 2^3 and 2^4 in juxtaposition similar to the description of 2^5 Chart, section 14; and 2^6 Chart, section 16. This chart has been divided into Upper and Lower halves for a similar reason, as Master Chart 2^9 , Fig. 10. The upper half includes Combinations 1-64, and the lower half, Combinations 65 to 128.

Occasionally it becomes necessary in dental study to obtain combinations of seven persons, places, or things, affected by such conditions, as present, or absent. The Master Chart 2⁷, Figure 16, will be found useful in such cases.

For example, take a case of seven pathological conditions being present when a particular part or organ is affected. The investigator will wish to know whether all the conditions taken together is the cause of the lesion, or whether any combination of them is the cause. Now, by consulting this Master Chart 2⁷, all the combinations possible are presented.

The combinations of the seven designated spectral colors, red, orange, yellow, indigo, blue and violet, are also interesting, ranging from white, a combination of all of these, to black, the absence of all of these, with 126 combinations in between. These possible combinations may be made from the Master Chart 2⁷, Fig. 16, by the simple method of designating these seven spectral colors by the seven letters of the alphabet, and substituting as formerly.

Another interesting application of the 2⁷ Chart is where an organist desires to study the possibilities of a church organ. These organs are usually divided into four sections, namely, Great, Swell, Choir, which are manuals, and the Pedal section.

Each of these sections has a complement of stops, each of which produces a characteristic tone. Various combinations of these tones produce different tonal affects.

Under the present heading, let us consider the choir section of a three manual organ, with seven stops, namely, (1) Melodia, (2) Gedacht, (3) Dulciana, (4) Vienna flute, (5) Clarinet, (6) Viol d'orchestre, and (7) Orchestral Oboe. If the organist wishes to be sure of trying all the combinations possible, he can use Master Chart 2⁷. Following methods outlined in this study, an organist may get all of the combinations up to sixteen stops.

PART VII.—DEALING WITH MASTER CHART 2⁸.

21. A MASTER CHART 2⁸ OF 256 COMBINATIONS.

This Master Chart has been the most useful of all in dental work, in assisting investigators to develop and check up formulae in Designs of Bridgework, and Partial Denture Work, or in standardizing and simplifying the present day methods of Impression Taking for Partials, and for other uses which may occur from time to time. This is so because the combinations of one-half of the teeth (eight in number) in either Upper or Lower jaw, have been drawn from this Chart by substituting the letters A-B-C-D-E-F-G-H for the third, second, and first molars, second and first bicuspid, cuspid, lateral and central respectively.

Part D

Part C

Part B

Part A

MASTER CHART OF 2 ⁸ COMBINATIONS = 256 COMBINATIONS				ROYAL COLLEGE OF DENTAL SURGEONS				GROUP
								RIGHT SEVEN
1 A B C D E F G H	17 A B C * E F G H	33 B C D * E F G H	49 A C D * E F G H	65 A C D * E F G H	81 A C D * E F G H	97 A C D * E F G H	113 C D * E F G H	SEVENS
2 A B C D E F G	18 A B C * E F G	34 B C D * E F G	50 A C D * E F G	66 A C D * E F G	82 A C D * E F G	98 A C D * E F G	114 C D * E F G	SIXES
3 A B C D * E F G H	19 A B C * * F G H	35 B C D * * F G H	51 A C D * * F G H	67 A C D * * F G H	83 A C D * * F G H	99 A C D * * F G H	115 C D * * F G H	FIVES
4 A B C D E * F G H	20 A B C * E * G H	36 B C D * E * G H	52 A C D * E * G H	68 A C D * E * G H	84 A C D * E * G H	100 A C D * E * G H	116 C D * E * G H	FOURS
5 A B C D * E F * H	21 A B C * * E F H	37 B C D * * E F H	53 A C D * * E F H	69 A C D * * E F H	85 A C D * * E F H	101 A C D * * E F H	117 C D * * E F H	THREES
6 A B C D * E F G	22 A B C * * E F	38 B C D * * E F	54 A C D * * E F	70 A B D * E R	86 A B * E F	102 B C * E F	118 C D * E F	TWOS
7 A B C D * F G	23 A B C * * F G	39 B C D * * F G	55 A C D * * F G	71 A B D * * F G	87 A B * * F G	103 B C * * F G	119 C D * * F G	ONES
8 A B C D * G H	24 A B C * * G H	40 B C D * * G H	56 A C D * * G H	72 A B D * E * G H	88 A B * * G H	104 B C * * G H	120 C D * * G H	
9 A B C D * * H	25 A B C * * * H	41 B C D * * * H	57 A C D * * * H	73 A B D * * E * H	89 A B * * * H	105 B C * * * H	121 C D * * * H	
10 A B C D * E G	26 A B C * * E G	42 B C D * * E G	58 A C D * * E G	74 A B D * * F * H	90 A B * * E G	106 B C * * E G	122 C D * * E G	
11 A B C D * F H	27 A B C * * F H	43 B C D * * F H	59 A C D * * F H	75 A B D * * G * H	91 A B * * F H	107 B C * * F H	123 C D * * F H	
12 A B C D * E	28 A B C * * E	44 B C D * * E	60 A C D * * E	76 A B D * * H	92 A B * * E	108 B C * * E	124 C D * * E	
13 A B C D * F	29 A B C * * F	45 B C D * * F	61 A C D * * F	77 A B D * * G	93 A B * * F	109 B C * * F	125 C D * * F	
14 A B C D * G	30 A B C * * G	46 B C D * * G	62 A C D * * G	78 A B D * * H	94 A B * * G	110 B C * * G	126 C D * * G	
15 A B C D * H	31 A B C * * H	47 B C D * * H	63 A C D * * H	79 A B D * * F	95 A B * * H	111 B C * * H	127 C D * * H	
16 A B C D *	32 A B C *	48 B C D *	64 A C D *	80 A B D *	96 A B *	112 B C *	128 C D *	
				129 A B D * E F G H	145 A C * E F G H	161 B D * E F G H	177 A * E F G H	SEVENS
65 A B D * E F G	81 A B * E F G	97 B C * E F G	113 C D * E F G	129 A B D * E F G	145 A C * E F G	161 B D * E F G	177 A * E F G	SIXES
66 A B D * F G	82 A B * F G	98 B C * F G	114 C D * F G	130 A B D * F G	146 A C * F G	162 B D * F G	178 A * F G	FIVES
67 A B D * G H	83 A B * G H	99 B C * G H	115 C D * G H	131 A B D * G H	147 A C * G H	163 B D * G H	179 A * G H	FOURS
68 A B D * H	84 A B * H	100 B C * H	116 C D * H	132 A B D * H	148 A C * H	164 B D * H	180 A * H	THREES
69 A B D * E	85 A B * E	101 B C * E	117 C D * E	133 A B D * F	149 A C * F	165 B D * F	181 A * F	TWOS
70 A B D * F	86 A B * F	102 B C * F	118 C D * F	134 A B D * G	150 A C * G	166 B D * G	182 A * G	ONES
71 A B D * G	87 A B * G	103 B C * G	119 C D * G	135 A B D * H	151 A C * H	167 B D * H	183 A * H	
72 A B D * E F	88 A B * * F	104 B C * * F	120 C D * * F	136 A B D * F	152 A C * F	168 B D * F	184 A * F	
73 A B D * F	89 A B * * F	105 B C * * F	121 C D * * F	137 A B D * G	153 A C * G	169 B D * G	185 A * G	
74 A B D * G	90 A B * * G	106 B C * * G	122 C D * * G	138 A B D * H	154 A C * H	170 B D * H	186 A * H	
75 A B D * E F	91 A B * * E	107 B C * * E	123 C D * * E	139 A B D * F	155 A C * F	171 B D * F	187 A * F	
76 A B D * F	92 A B * * F	108 B C * * F	124 C D * * F	140 A B D * G	156 A C * G	172 B D * G	188 A * G	
77 A B D * G	93 A B * * G	109 B C * * G	125 C D * * G	141 A B D * H	157 A C * H	173 B D * H	189 A * H	
78 A B D * E	94 A B * * E	110 B C * * E	126 C D * * E	142 A B D * F	158 A C * F	174 B D * F	190 A * F	
79 A B D * F	95 A B * * F	111 B C * * F	127 C D * * F	143 A B D * G	159 A C * G	175 B D * G	191 A * G	
80 A B D * G	96 A B * * G	112 B C * * G	128 C D * * G	144 A B D * H	160 A C * H	176 B D * H	192 A * H	
81 A B D *	97 A B *	113 B C *	129 C D *	145 A B D *	161 A C *	177 B D *	193 A *	
129 A B D * E F G H	145 A C * E F G H	161 B D * E F G H	177 A * E F G H	129 A B D * E F G H	145 A C * E F G H	161 B D * E F G H	177 A * E F G H	SEVENS
130 A B D * F G	146 A C * F G	162 B D * F G	178 A * F G	130 A B D * F G	146 A C * F G	162 B D * F G	178 A * F G	SIXES
131 A B D * G H	147 A C * G H	163 B D * G H	179 A * G H	131 A B D * G H	147 A C * G H	163 B D * G H	179 A * G H	FIVES
132 A B D * H	148 A C * H	164 B D * H	180 A * H	132 A B D * H	148 A C * H	164 B D * H	180 A * H	FOURS
133 A B D * E	149 A C * E	165 B D * E	181 A * E	133 A B D * E	149 A C * E	165 B D * E	181 A * E	THREES
134 A B D * F	150 A C * F	166 B D * F	182 A * F	134 A B D * F	150 A C * F	166 B D * F	182 A * F	TWOS
135 A B D * G	151 A C * G	167 B D * G	183 A * G	135 A B D * G	151 A C * G	167 B D * G	183 A * G	ONES
136 A B D * H	152 A C * H	168 B D * H	184 A * H	136 A B D * H	152 A C * H	168 B D * H	184 A * H	
137 A B D * E F	153 A C * * F	169 B D * * F	185 A * * F	137 A B D * E F	153 A C * * F	169 B D * * F	185 A * * F	
138 A B D * F	154 A C * * F	170 B D * * F	186 A * * F	138 A B D * F	154 A C * * F	170 B D * * F	186 A * * F	
139 A B D * G	155 A C * * G	171 B D * * G	187 A * * G	139 A B D * G	155 A C * * G	171 B D * * G	187 A * * G	
140 A B D * H	156 A C * * H	172 B D * * H	188 A * * H	140 A B D * H	156 A C * * H	172 B D * * H	188 A * * H	
141 A B D * E	157 A C * * E	173 B D * * E	189 A * * E	141 A B D * E	157 A C * * E	173 B D * * E	189 A * * E	
142 A B D * F	158 A C * * F	174 B D * * F	190 A * * F	142 A B D * F	158 A C * * F	174 B D * * F	190 A * * F	
143 A B D * G	159 A C * * G	175 B D * * G	191 A * * G	143 A B D * G	159 A C * * G	175 B D * * G	191 A * * G	
144 A B D * H	160 A C * * H	176 B D * * H	192 A * * H	144 A B D * H	160 A C * * H	176 B D * * H	192 A * * H	
145 A B D *	161 A C *	177 B D *	193 A *	145 A B D *	161 A C *	177 B D *	193 A *	
193 A B D * E F G H	209 C * E F G H	225 D * E F G H	241 * E F G H	193 A B D * E F G H	209 C * E F G H	225 D * E F G H	241 * E F G H	SEVENS
194 A B D * F G	210 C * F G	226 D * F G	242 * F G	194 A B D * F G	210 C * F G	226 D * F G	242 * F G	SIXES
195 A B D * G H	211 C * G H	227 D * G H	243 * G H	195 A B D * G H	211 C * G H	227 D * G H	243 * G H	FIVES
196 A B D * H	212 C * H	228 D * H	244 * H	196 A B D * H	212 C * H	228 D * H	244 * H	FOURS
197 A B D * E	213 C * E	229 D * E	245 * E	197 A B D * E	213 C * E	229 D * E	245 * E	THREES
198 A B D * F	214 C * F	230 D * F	246 * F	198 A B D * F	214 C * F	230 D * F	246 * F	TWOS
199 A B D * G	215 C * G	231 D * G	247 * G	199 A B D * G	215 C * G	231 D * G	247 * G	ONES
200 A B D * H	216 C * H	232 D * H	248 * H	200 A B D * H	216 C * H	232 D * H	248 * H	
201 A B D * E F	217 C * * F	233 D * * F	249 * * F	201 A B D * E F	217 C * * F	233 D * * F	249 * * F	
202 A B D * F	218 C * * F	234 D * * F	250 * * F	202 A B D * F	218 C * * F	234 D * * F	250 * * F	
203 A B D * G	219 C * * G	235 D * * G	251 * * G	203 A B D * G	219 C * * G	235 D * * G	251 * * G	
204 A B D * H	220 C * * H	236 D * * H	252 * * H	204 A B D * H	220 C * * H	236 D * * H	252 * * H	
205 A B D * E	221 C * * E	237 D * * E	253 * * E	205 A B D * E	221 C * * E	237 D * * E	253 * * E	
206 A B D * F	222 C * * F	238 D * * F	254 * * F	206 A B D * F	222 C * * F	238 D * * F	254 * * F	
207 A B D * G	223 C * * G	239 D * * G	255 * * G	207 A B D * G	223 C * * G	239 D * * G	255 * * G	
208 A B D * H	224 C * * H	240 D * * H	256 * * H	208 A B D * H	224 C * * H	240 D * * H	256 * * H	
209 A B D *	225 C *	241 D *	257 A *	209 A B D *	225 C *	241 D *	257 A *	
241 A B D * E F G H	257 C * E F G H	273 D * E F G H	289 * E F G H	241 A B D * E F G H	257 C * E F G H	273 D * E F G H	289 * E F G H	SEVENS
242 A B D * F G	258 C * F G	274 D * F G	290 * F G	242 A B D * F G	258 C * F G	274 D * F G	290 * F G	SIXES
243 A B D * G H	259 C * G H	275 D * G H	291 * G H	243 A B D * G H	259 C * G H	275 D * G H	291 * G H	FIVES
244 A B D * H	260 C * H	276 D * H	292 * H	244 A B D * H	260 C * H	276 D * H	292 * H	FOURS
245 A B D * E	261 C * E	277 D * E	293 * E	245 A B D * E	261 C * E	277 D * E	293 * E	THREES
246 A B D * F	262 C * F	278 D * F	294 * F	246 A B D * F	262 C * F	278 D * F	294 * F	TWOS
247 A B D * G	263 C * G	279 D * G	295 * G	247 A B D * G	263 C * G	279 D * G	295 * G	ONES
248 A B D * H	264 C * H	280 D * H	296 * H	248 A B D * H	264 C * H	280 D * H	296 * H	
249 A B D * E F	265 C * * F	281 D * * F	297 * * F	249 A B D * E F	265 C * * F	281 D * * F	297 * * F	
250 A B D * F	266 C * * F	282 D * * F	298 * * F	250 A B D * F	266 C * * F	282 D * * F	298 * * F	
251 A B D * G	267 C * * G	283 D * * G	299 * * G	251 A B D * G	267 C * * G	283 D * * G	299 * * G	
252 A B D * H	268 C * * H	284 D * * H	300 * * H	252 A B D * H	268 C * * H	284 D * * H	300 * * H	
253 A B D * E	269 C * * E	285 D * * E	301 * * E	253 A B D * E	269 C * * E	285 D * * E	301 * * E	
254 A B D * F	270 C * * F	286 D * * F	302 * * F	254 A B D * F	270 C * * F	286 D * * F	302 * * F	
255 A B D * G	271 C * * G	287 D * * G	303 * * G	255 A B D * G	271 C * * G	287 D * * G	303 * * G	
256 A B D * H	272 C * * H	288 D * * H	304 * * H	256 A B D * H	272 C * * H	288 D * * H	304 * * H	
257 A B D *	273 C *	289 D *	305 A *	257 A B D *	273 C *	289 D *	305 A *	
273 A B D * E F G H	289 C * E F G H	305 D * E F G H	321 * E F G H	273 A B D * E F G H	289 C * E F G H	305 D * E F G H	321 * E F G H	SEVENS
274 A B D * F G	290 C * F G	306 D * F G	322 * F G	274 A B D * F G	290 C * F G	306 D * F G	322 * F G	SIXES
275 A B D * G H	291 C * G H	307 D * G H	323 * G H	275 A B D * G H	291 C * G H	307 D * G H	323 * G H	FIVES
276 A B D * H	292 C * H	308 D * H	324 * H	276 A B D * H	292 C * H	308 D * H	324 * H	FOURS
277 A B D * E	293 C * E	309 D * E	325 * E	277 A B D * E	293 C * E	309 D * E	325 * E	THREES
278 A B D * F	294 C * F	310 D * F	326 * F	278 A B D * F	294 C * F	310 D * F	326 * F	TWOS
279 A B D * G	295 C * G	311 D * G	327 * G	279 A B D * G	295 C * G	311 D * G	327 * G	ONES
280 A B D * H	296 C * H	312 D * H	328 * H	280 A B D * H	296 C * H	312 D * H	328 * H	
281 A B D * E F	297 C * * F	313 D * * F	329 * * F	281 A B D * E F	297 C * * F	313 D * * F	329 * * F	
282 A B D * F	298 C * * F	314 D * * F	330 * * F	282 A B D * F	298 C * * F	314 D * * F	330 * * F	
283 A B D * G	299 C * * G	315 D * * G	331 * * G	283 A B D * G	299 C * * G	315 D * * G	331 * * G	
284 A B D * H	300 C * * H	316 D * * H	332 * * H	284 A B D * H	300 C * * H	316 D * * H	332 * * H	
285 A B D * E	301 C * * E	317 D * * E	333 * * E	285 A B D * E	301 C * * E	317 D * * E	333 * * E	
286 A B D * F	302 C * * F	318 D * * F	334 * * F	286 A B D * F	302 C * * F	318 D * * F	334 * * F	
287 A B D * G	303 C * * G	319 D * * G	335 * * G	287 A B D * G	303 C * * G	319 D * * G	335 * * G	
288 A B D * H	304 C * * H	320 D * * H	336 * * H	288 A B D * H	304 C * * H	320 D * * H	336 * * H	
289 A B D *	305 C *	321 D *	337 A *	289 A B D *	305 C *	321 D *	337 A *	
321 A B D * E F G H	337 C * E F G H	353 D * E F G H	369 * E F G H	321 A B D * E F G H	337 C * E F G H	353 D * E F G H	369 * E F G H	SEVENS
322 A B D * F G	338 C * F G	354 D * F G	370 * F G	322 A B D * F G	338 C * F G	354 D * F G	370 * F G	SIXES
323 A B D * G H	339 C * G H	355 D * G H	371 * G H	323 A B D * G H	339 C * G H	355 D * G H	371 * G H	FIVES
324 A B D * H	340 C * H	356 D * H	372 * H	324 A B D * H	340 C * H	356 D * H	372 * H	FOURS
325 A B D * E	341 C * E	357 D * E	373 * E	325 A B D * E	341 C * E	357 D * E	373 * E	THREES

Redistribution of any of the combinations of teeth into classes, as shown in this article, will be of material assistance in reducing the loading problem, in Partial Denture Work, to simple formulae.

Any classification in dentistry is an effort to redistribute cases into classes; each class to be governed more or less by simple rules, and to be treated by more or less simple methods. This standardizes and simplifies dental problems for the practitioner.

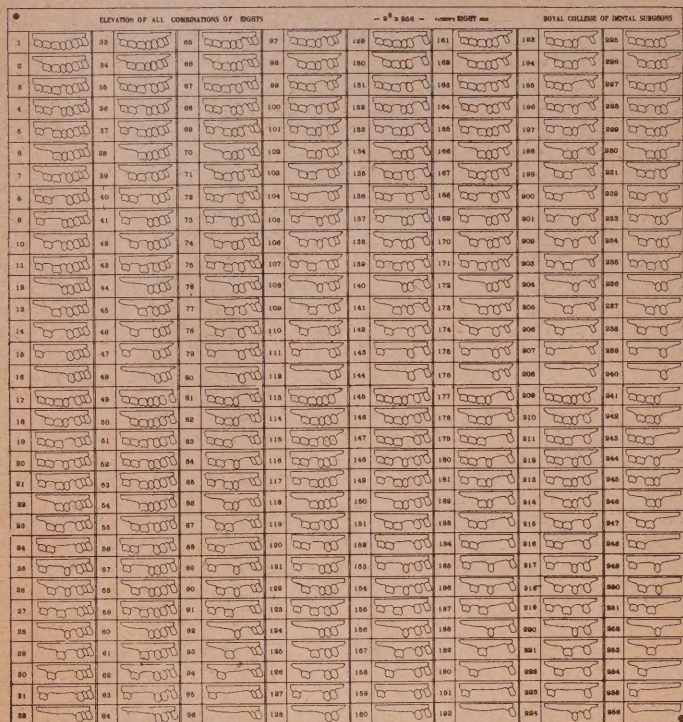


Figure No. 18. Elevation of all combinations of the maxillary teeth on right side. These have all been developed from Master Chart Figure 17, by the substitution method described in the text.

For purposes of investigation, the plan and elevation charts, Figs. 18-19-20-21, may be treated in a similar manner as plan Fig. 11A, and arranged on soft wood boards with pins. As an example of rearrangement see Fig. 15, where we have the 64 Combinations of all the six teeth arranged under groups of sixes, of fives, of fours, of threes, of twos, of ones, and of nones.

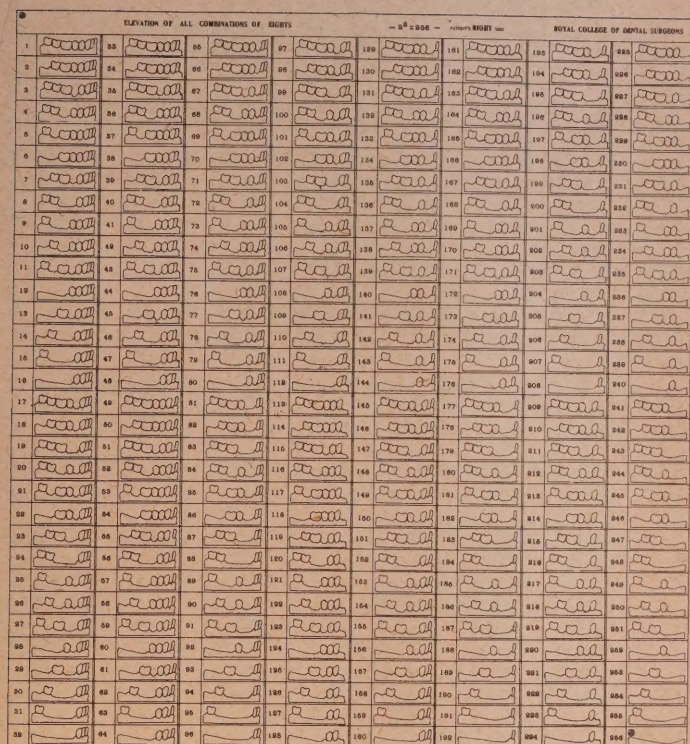


Figure No. 19. Elevation of all combinations of the mandibular teeth on right side. These have also been developed from Master Chart Figure 17, by the substitution method described in the text.

PATIENT'S RIGHT		A FOURS	B THREE	C THREE	D THREE	E THREE	F TWOS	G TWOS	H TWOS
SAME PROBLEM AS No's. 2-17 ETC.	FOURS								
	A	1	17	33	49	65	81	97	113
	THREE								
SAME PROBLEM AS No's. 7-23 ETC.	B	2	18	34	50	66	82	98	114
	THREE								
	C	3	19	35	51	67	83	99	115
SAME PROBLEM AS No's. 10-26 ETC.	THREE								
	D	4	20	36	52	68	84	100	116
	THREE								
	E	5	21	37	53	69	85	101	117
	TWOS								
	F	6	22	38	54	70	86	102	118
	TWOS								
	G	7	23	39	55	71	87	103	119
	TWOS								
SAME PROBLEM AS No's. 14-30 ETC.	H	8	24	40	56	72	88	104	120
	TWOS								
	I	9	25	41	57	73	89	105	121
	TWOS								
	J	10	26	42	58	74	90	106	122
	TWOS								
	K	11	27	43	59	75	91	107	123
	ONES								
	L	12	28	44	60	76	92	108	124
	ONES								
	M	13	29	45	61	77	93	109	125
	ONES								
	N	14	30	46	62	78	94	110	126
	ONES								
	O	15	31	47	63	79	95	111	127
	NONE								
	P	16	32	48	64	80	96	112	128

Figure 20. Chart of Plan of all the Upper Symmetrical Combinations, 2⁸ or 256 in all.

Note:—This is one Chart divided into two sections, on account of space. In this Chart, (on the Patient's right or the observer's left) each combination, from third molar to central, has been developed by the substitution method as in Figures 18 and 19.

TWOS	TWOS	TWOS	ONES	ONES	ONES	ONES	P NONE
129	145	161	177	193	209	225	241
130	146	162	178	194	210	226	242
131	147	163	179	195	211	227	243
132	148	164	180	196	212	228	244
133	149	165	181	197	213	229	245
134	150	166	182	198	214	230	246
135	151	167	183	199	215	231	247
136	152	168	184	200	216	232	248
137	153	169	185	201	217	233	249
138	154	170	186	202	218	234	250
139	155	171	187	203	219	235	251
140	156	172	188	204	220	236	252
141	157	173	189	205	221	237	253
142	158	174	190	206	222	238	254
143	159	175	191	207	223	239	255
144	160	176	192	208	224	240	256

Figure 20. Chart of Plan of all the Upper Symmetrical Combinations, 2⁸ or 256 in all.

Again (on the patient's left or the observer's right,) each tooth has been sketched in, showing the same combination.

This results in a Chart of ALL symmetrical combinations:—that is to say, with the same teeth present or absent on each side. The use of the index border will be discovered in section 22.

SAME PROBLEM AS No's. 2-17 ETC.	P								
	FOURS	1	17	33	49	65	81	97	113
—	O								
	THREES	2	18	34	50	66	82	98	114
SAME PROBLEM AS No's. 7-23 ETC.	N								
	THREES	3	19	35	51	67	83	99	115
SAME PROBLEM AS No's. 10-28 ETC.	M								
	THREES	4	20	36	52	68	84	100	116
—	L								
	THREES	5	21	37	53	69	85	101	117
—	K								
	TWOS	6	22	38	54	70	86	102	118
—	J								
	TWOS	7	23	39	55	71	87	103	119
SAME PROBLEM AS No's. 14-30 ETC.	I								
	TWOS	8	24	40	56	72	88	104	120
—	H								
	TWOS	9	25	41	57	73	89	105	121
—	G								
	TWOS	10	26	42	58	74	90	106	122
—	F								
	TWOS	11	27	43	59	75	91	107	123
—	E								
	ONES	12	28	44	60	76	92	108	124
—	D								
	ONES	13	29	45	61	77	93	109	125
—	C								
	ONES	14	30	46	62	78	94	110	126
—	B								
	ONES	15	31	47	63	79	95	111	127
—	A								
	NONE	16	32	48	64	80	96	112	128
PATIENT'S RIGHT SIDE		FOURS A	THREES B	THREES C	THREES D	THREES E	TWOS F	TWOS G	TWOS H

Figure 21. Chart of Plan of all Lower Symmetrical Combinations, 2^s or 256 in all.

Note:—This is one chart divided into two sections, on account of space. In this Chart (the Patient's right or the observer's left) each Combination, from third molar to central has been developed by the substitution method, as in Figures 18 and 19.

Figure 21. Chart of Plan of all Lower Symmetrical Combinations, 2^s or 256 in all.

Again (on the Patient's left or the observer's right) each tooth has been sketched in, showing the same combination.

This results in a Chart of ALL the symmetrical combinations:—that is to say, with the same teeth present or absent on each side. The use of the index border will be discovered in section 22.

22. INDEXING OF 2⁸ SYMMETRICAL DENTAL CHARTS.

The juxtaposition* method of building the Master Chart will result in dental charts which lend themselves readily to indexing on the rectilinear co-ordinate system. For example, in Fig. 20, there are 256 different combinations. The method of finding any particular symmetrical combination is worked out as follows:

Suppose we desire to study a case which shows on the right anterior half the central, cuspid, and first bicuspid, and on the right posterior half, the first and second molars.

On the upper horizontal index (the border on the top of figure 20) find the combination of central, cuspid and first bicuspid, (fourth from the left hand side, number D) place the index finger of the right hand on it. Holding the finger there, find in the lateral-vertical index, (the border on the observers left hand side of figure 20) the combination of first and third molar. This will be found in section K, (the sixth from the bottom). Then place the index finger of the left hand on this space, and now cause both index fingers to travel at right angles together. They will meet in space number 59, which is the desired symmetrical combination. Any combination in the entire 256 may be rapidly found by this method.

The method of proceeding for cases in the lower is the same as above, except that the horizontal index will be found at the bottom of the chart (fig. 21) instead of at the top.

PART VIII.—DEALING WITH 2¹⁰, 2¹², 2¹⁶, AND OTHER COMBINATIONS.

23. A SERIES OF 2¹⁰ COMBINATIONS (1024) WITH INDEX.

Here follows a series of sixteen Charts showing all of the possible combinations between the upper left lateral and the upper right third molar inclusive, ten teeth in all, showing 2¹⁰ or 1024 combinations. This series was developed in the Royal College of Dental Surgeons, Toronto, at the suggestion of Professor I. H. Ante, as an aid in standardizing and simplifying Bridge Design and Construction. This series is built up of a juxtaposition of 2³ (3 molars) with 2³ (2 bicuspids and 1 cuspid); and also with 2⁴ (anterior 4) as subsequently described in index.

The result of this juxtaposition is a simple method of indexing as described in section 24.

*For description of the juxtaposition method, see section 14.



Figure No. 22. Plate 1, Index, four anterior teeth.



Figure No. 22. Plate 2, Index, three anterior teeth, both centrals and right lateral.

INDEX	ALL COMBINATIONS OF TENS $2^{10} = 1024$ COMBINATIONS										INDEX	ANTERIOR THREES	PLATE 3
CLAPTON 1ST MOLAR	1	9	17	25	33	41	49	57					
CLAPTON 2ND MOLAR	2	10	18	26	34	42	50	58					
CLAPTON 3RD MOLAR	3	11	19	27	35	43	51	59					
CLAPTON 4TH MOLAR	4	12	20	28	36	44	52	60					
CLAPTON 5TH MOLAR	5	13	21	29	37	45	53	61					
CLAPTON 6TH MOLAR	6	14	22	30	38	46	54	62					
CLAPTON 7TH MOLAR	7	15	23	31	39	47	55	63					
CLAPTON 8TH MOLAR	8	16	24	32	40	48	56	64					

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Figure No. 22. Plate 3, Index, three anterior teeth, both centrals and left lateral.

INDEX	ALL COMBINATIONS OF TENS $2^{10} = 1024$ COMBINATIONS										INDEX	ANTERIOR THREES	PLATE 4
CLAPTON 1ST MOLAR	1	9	17	25	33	41	49	57					
CLAPTON 2ND MOLAR	2	10	18	26	34	42	50	58					
CLAPTON 3RD MOLAR	3	11	19	27	35	43	51	59					
CLAPTON 4TH MOLAR	4	12	20	28	36	44	52	60					
CLAPTON 5TH MOLAR	5	13	21	29	37	45	53	61					
CLAPTON 6TH MOLAR	6	14	22	30	38	46	54	62					
CLAPTON 7TH MOLAR	7	15	23	31	39	47	55	63					
CLAPTON 8TH MOLAR	8	16	24	32	40	48	56	64					

52 ROYAL COLLEGE OF DENTAL SURGEONS TORONTO, CANADA
Figure No. 22. Plate 4, Index, three anterior teeth, both laterals, and right central.

INDEX	ALL COMBINATIONS OF TENS $2^{10} = 1024$ COMBINATIONS										INDEX	ANTERIOR THREES	PLATE 5
1											1		57
2											2		58
3											3		59
4											4		60
5											5		61
6											6		62
7											7		63
8											8		64
9											9		65
10											10		66
11											11		67
12											12		68
13											13		69
14											14		70
15											15		71
16											16		72
17											17		73
18											18		74
19											19		75
20											20		76
21											21		77
22											22		78
23											23		79
24											24		80
25											25		81
26											26		82
27											27		83
28											28		84
29											29		85
30											30		86
31											31		87
32											32		88
33											33		89
34											34		90
35											35		91
36											36		92
37											37		93
38											38		94
39											39		95
40											40		96
41											41		97
42											42		98
43											43		99
44											44		100
45											45		101
46											46		102
47											47		103
48											48		104
49											49		105
50											50		106
51											51		107
52											52		108
53											53		109
54											54		110
55											55		111
56											56		112
57											57		113
58											58		114
59											59		115
60											60		116
61													

INDEX	ALL COMBINATIONS OF TENS $2^{10} = 1024$ COMBINATIONS										INDEX	ANTERIOR TWO	PLATE 7
1											1		57
2											2		58
3											3		59
4											4		60
5											5		61
6											6		62
7											7		63
8											8		64

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TORONTO, CANADA

Figure No. 22, Plate 7, Index, two anterior teeth, both centrals.

INDEX	ALL COMBINATIONS OF TENS $2^{10} = 1024$ COMBINATIONS										INDEX	ANTERIOR TWO	PLATE 8
1											1		57
2											2		58
3											3		59
4											4		60
5											5		61
6											6		62
7											7		63
8											8		64

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TORONTO, CANADA

Figure No. 22, Plate 8, Index, two anterior teeth, left central and lateral.

INDEX	ALL COMBINATIONS OF TENS $2^{10} = 1024$ COMBINATIONS										INDEX	ANTERIOR TWOS	PLATE 9
1													
2													
3													
4													
5													
6													
7													
8													
INDEX	1ST ANT. MOLAR	2ND ANT. MOLAR	3RD ANT. MOLAR	1ST PREM.	2ND PREM.	3RD PREM.	1ST MOLAR	2ND MOLAR	3RD MOLAR	1ST PREM.	2ND PREM.	3RD PREM.	1ST MOLAR

45 ROYAL COLLEGE OF DENTAL SURGEONS - TORONTO, CANADA.
Figure No. 22, Plate 9, Index, two anterior teeth, right lateral and left central.

INDEX	ALL COMBINATIONS OF TENS $2^{10} = 1024$ COMBINATIONS										INDEX	ANTERIOR TWOS	PLATE 10
1													
2													
3													
4													
5													
6													
7													
8													
INDEX	1ST ANT. MOLAR	2ND ANT. MOLAR	3RD ANT. MOLAR	1ST PREM.	2ND PREM.	3RD PREM.	1ST MOLAR	2ND MOLAR	3RD MOLAR	1ST PREM.	2ND PREM.	3RD PREM.	1ST MOLAR

64 ROYAL COLLEGE OF DENTAL SURGEONS - TORONTO, CANADA.
Figure No. 22, Plate 10, Index, two anterior teeth, right central and left lateral.

INDEX	ALL COMBINATIONS OF TENS $2^{10} = 1024$ COMBINATIONS										INDEX	ANTERIOR TWOS	PLATE 11
CLUMP 1ST AND 2ND MOLARS	1	9	17	25	33	41	49	57					
CLUMP 1ST AND 2ND MOLARS	2	10	18	26	34	42	50	58					
CLUMP 1ST AND 2ND MOLARS	3	11	19	27	35	43	51	59					
CLUMP 1ST AND 2ND MOLARS	4	12	20	28	36	44	52	60					
CLUMP 1ST AND 2ND MOLARS	5	13	21	29	37	45	53	61					
CLUMP 1ST AND 2ND MOLARS	6	14	22	30	38	46	54	62					
CLUMP 1ST AND 2ND MOLARS	7	15	23	31	39	47	55	63					
CLUMP 1ST AND 2ND MOLARS	8	16	24	32	40	48	56	64					
INDEX	1ST AND 2ND MOLARS	2ND MOLAR	1ST AND 2ND MOLARS	2ND MOLAR	1ST AND 2ND MOLARS	2ND MOLAR	1ST AND 2ND MOLARS	2ND MOLAR	1ST AND 2ND MOLARS	2ND MOLAR	1ST AND 2ND MOLARS	2ND MOLAR	INDEX

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TORONTO, CANADA

Figure No. 22, Plate 11, Index, two anterior teeth, both laterals.

INDEX	ALL COMBINATIONS OF TENS $2^{10} = 1024$ COMBINATIONS										INDEX	ANTERIOR ONES	PLATE 12
CLUMP 1ST AND 2ND MOLARS	1	9	17	25	33	41	49	57					
CLUMP 1ST AND 2ND MOLARS	2	10	18	26	34	42	50	58					
CLUMP 1ST AND 2ND MOLARS	3	11	19	27	35	43	51	59					
CLUMP 1ST AND 2ND MOLARS	4	12	20	28	36	44	52	60					
CLUMP 1ST AND 2ND MOLARS	5	13	21	29	37	45	53	61					
CLUMP 1ST AND 2ND MOLARS	6	14	22	30	38	46	54	62					
CLUMP 1ST AND 2ND MOLARS	7	15	23	31	39	47	55	63					
CLUMP 1ST AND 2ND MOLARS	8	16	24	32	40	48	56	64					
INDEX	1ST AND 2ND MOLARS	2ND MOLAR	1ST AND 2ND MOLARS	2ND MOLAR	1ST AND 2ND MOLARS	2ND MOLAR	1ST AND 2ND MOLARS	2ND MOLAR	1ST AND 2ND MOLARS	2ND MOLAR	1ST AND 2ND MOLARS	2ND MOLAR	INDEX

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TORONTO, CANADA

Figure No. 22, Plate 12, Index, one anterior tooth, right lateral.

INDEX	ALL COMBINATIONS OF TENS				$2^{10} = 1024$ COMBINATIONS				INDEX	ANTERIOR ONES	PLATE 13
CLIPPER 1ST DENT RIGHT											
CLIPPER 1ST DENT LEFT											
CLIPPER 1ST DENT RIGHT											
CLIPPER 1ST DENT LEFT											
CLIPPER 1ST DENT RIGHT											
CLIPPER 1ST DENT LEFT											
CLIPPER 1ST DENT RIGHT											
CLIPPER 1ST DENT LEFT											
INDEX											

56 ROYAL COLLEGE OF DENTAL SURGEONS

TORONTO, CANADA

Figure No. 22, Plate 13, Index, one anterior tooth, right central.

INDEX	ALL COMBINATIONS OF TENS				$2^{10} = 1024$ COMBINATIONS				INDEX	ANTERIOR ONES	PLATE 14
CLIPPER 1ST DENT RIGHT											
CLIPPER 1ST DENT LEFT											
CLIPPER 1ST DENT RIGHT											
CLIPPER 1ST DENT LEFT											
CLIPPER 1ST DENT RIGHT											
CLIPPER 1ST DENT LEFT											
CLIPPER 1ST DENT RIGHT											
CLIPPER 1ST DENT LEFT											
INDEX											

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TORONTO, CANADA

Figure No. 22, Plate 14, Index, one anterior tooth, left central.

INDEX	ALL COMBINATIONS OF TENS $2^{10} = 1024$ COMBINATIONS										INDEX	ANTERIOR ONES	PLATE 15
1											15		
2											15		
3											15		
4											15		
5											15		
6											15		
7											15		
8											15		
9											15		
10											15		

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TORONTO, CANADA

Figure No. 22, Plate 15, Index, one anterior tooth, left lateral.

INDEX	ALL COMBINATIONS OF TENS $2^{10} = 1024$ COMBINATIONS										INDEX	ANTERIOR NONE	PLATE 16
1											16		
2											16		
3											16		
4											16		
5											16		
6											16		
7											16		
8											16		
9											16		
10											16		

64 ROYAL COLLEGE OF DENTAL SURGEONS

TORONTO, CANADA

Figure 22, Plate 16, Index, no anterior teeth. From the foregoing the function of the anterior four as a plate index is noted. The function of the side and bottom indexes is noted, Section 24.

A		INDEX FOR PLATE NUMBER USING			B
ANTERIOR FOURS GROUP		COMBINATIONS OF FOUR ANTERIOR TEETH			
USE		COMBINATIONS	TEETH	SEE PLATE	
COMBINATIONS →		FOURS		1	
FOR PLATE INDEX		THREES		2	
A		••		3	
PATIENT'S RIGHT SIDE		••		4	
RIGHT ANTERIOR B GROUP		••		5	
RIGHT POSTERIOR C GROUP		TWOS		6	
		••		7	
		••		8	
		••		9	
		••		10	
		••		11	
		ONES		12	
		••		13	
		••		14	
		••		15	
		NONES		16	
C					
EXAMPLE					

ROYAL COLLEGE OF DENTAL SURGEONS

Figure No. 23. An index for use in 2^{10} Combinations as shown, Figure 22, plates, 1-16. Section A is the grouping to be used in using index of anterior four (plate index); and after the plate is found, right anterior group and right posterior group are used for locating combination on the plate. Section B is the plate index in groups of fours, threes, twos, ones, and nones, with groups of teeth in centre column, and plate number on adjacent column to right. Section C is an example.

24. THE INDEX FOR 2^{10} COMBINATIONS.

An index has been provided for the foregoing 2^{10} series by which any of the 1024 combinations may be readily obtained. This method is first to divide the case desired into three sections of (1) Anterior fours, and (2) Right anterior group, and (3) Right posterior group, as noted Figure 23, Section A. The anterior four group serves as the index for locating the proper plate, while the right anterior three, and right posterior three, locate the combination on this plate, already determined from the anterior fours. Using the example in figure 23, section C, it is noted that in the anterior four group two teeth are present. Referring to index for plate number figure 23 section B, and searching among the twos, this combination is found

opposite plate number 10. This plate is then located, and the index finger of the left hand is placed over the two bicuspid (as in right anterior group of example) on the left hand index column (second space from the top), while the right hand index finger is placed on the second molar (as found in the right posterior group of the example) which is the third space from the end on the lower horizontal index column. The fingers are caused to travel together at right angles, meeting on combination 42 plate 10, which is the combination desired. Any combination may be found in like manner.

25. REVERSE IN 2^{10} SERIES WHICH DOUBLE THE EFFICIENCY OF THIS OR OTHER CHARTS.

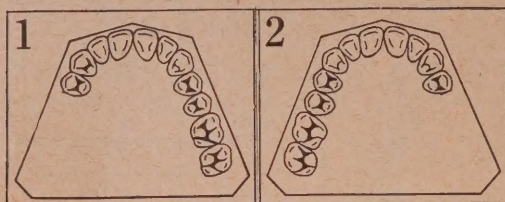


Figure No. 24. A Given Case and its Reverse. As described in the Text.

In Fig. 24 take the given case (1), the reverse (2) will be noted as being similar, except that the condition is located on the opposite side of the mouth. This consideration is of importance in design as it will reduce the number of combinations approximately by half. This relationship of Reverse, along with the additional relationship of Inverse, and Reverse-inverse, are further discussed in the 2^{16} chart, section 29.

In the foregoing series figure 22, plates 1-16, while intended especially for a study in Bridgework, shows only the combinations of ten teeth from the third molar on one side to the lateral on the other. For the purpose of Design this is sufficient, because all the combinations occurring on one side are reverses of those on the other. Hence, in order to keep the number of these combinations to a minimum, those on one side only are shown in figure 22, plates 1-16. To show the other side an additional series would have to be prepared. This was considered unnecessary, because the design of Bridgework or other types of restoration would be the same, only on the reverse on opposite side.

26. A SERIES OF 2^{12} COMBINATIONS (4096) WITH INDEX.

This series is useful for the study of hypotheses concerning the proper loading of teeth, or other similar studies. Loading is the allocation of the pressure of mastication on (a) root support, (b) mucosa support, or (c) a combination support of both root and mucosa. This is done in the fourth stage of design. Loading, in other words, is the use of occlusal rests for both root and combination support; or the non-use of occlusal rests where mucosa support is relied upon. See Bulletin No. 5, Canadian Dental Research Foundation, May, 1922, Oral Health Sept., 1922. Dental Summary, Dec., 1922, and Journal of American Dental Association, Sept., 1922.

It will be readily conceded that the peridontia of the posterior twelve teeth are best fitted to carry the stress of mastication. A table of combinations of the posterior twelve teeth (built virtually from the plan of the posterior six teeth Fig. 11A) follows, in 64 plates (Fig. 25, plates 1-64). Each plate carries 64 combinations, showing a total of 2^{12} or 4,096 combinations. As in preceding instances, in which teeth are left in to complete the picture (Figs. 7B, 7C, 11B, 12B, and 22) the anterior four teeth in this series remain in each picture unchanged, to complete the picture.

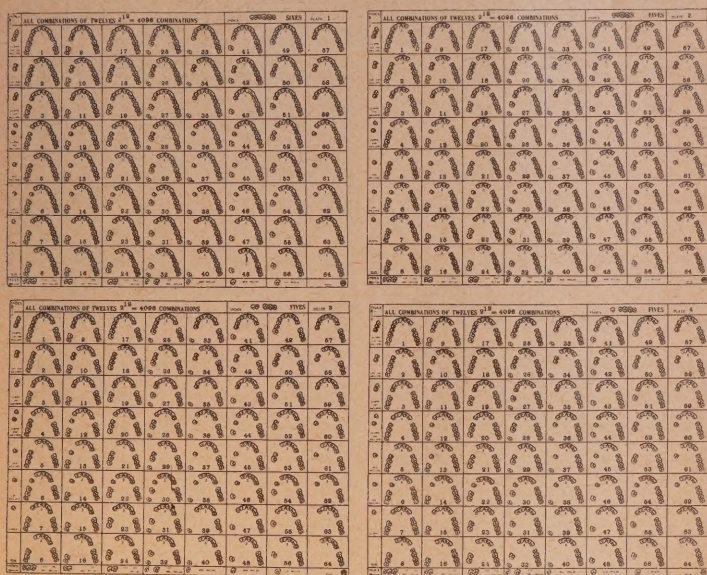


Figure No. 25, Plates 1-2-3-4.

Plate 1. Index, Six Posterior teeth;—Cuspid, two Bicuspsids, three Molars.

Plate 2. Index, Five posterior teeth;—two Bicuspsids and three Molars.

Plate 3. Index, Five Posterior teeth;—Cuspid, 1st Bicuspid, and three Molars.

Plate 4. Index, Five Posterior teeth;—Cuspid, 2nd Bicuspid, and three Molars.

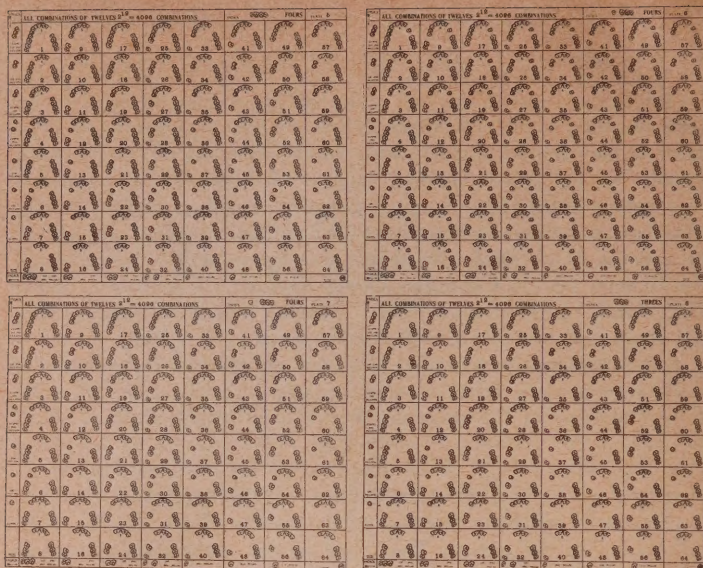


Figure 25. Plates 5-6-7-8.

Plate 5. Index, Four Posterior teeth;—2nd Bicuspid and three Molars.

Plate 6. Index, Four Posterior teeth;—1st Bicuspid and three Molars.

Plate 7. Index, Four Posterior teeth;—Cuspid and three Molars.

Plate 8. Index, Three Posterior teeth;—three Molars.

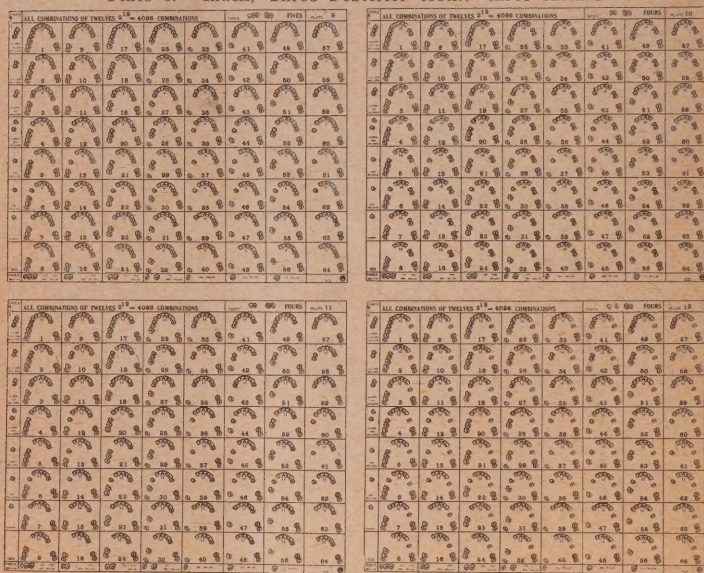


Figure No. 25. Plates 9-10-11-12.

Plate 9. Index, Five Posterior teeth;—Cuspid, two Bicuspids, 2nd and 3rd Molars.

Plate 10. Index, Four Posterior teeth;—two Bicuspids, 2nd and 3rd Molars.

Plate 11. Index, Four Posterior teeth;—Cuspid, 1st Bicuspid, 2nd and 3rd Molars.

Plate 12. Index, Four Posterior teeth;—Cuspid, 2nd Bicuspid, 2nd and 3rd Molars.

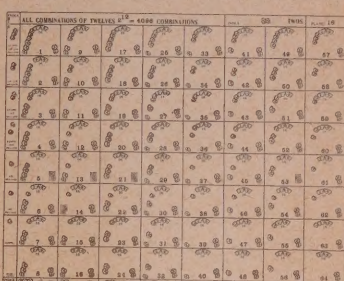
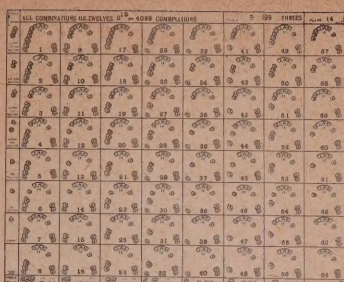
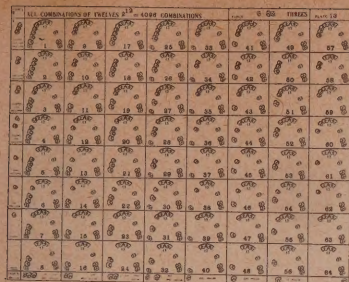


Figure No. 25. Plates 13-14-15-16.
 Plate 13. Index, Three Posterior teeth;—2nd Bicuspid, 2nd and 3rd Molars.
 Plate 14. Index, Three Posterior teeth;—1st Bicuspid, 2nd and 3rd Molars.
 Plate 15. Index, Three Posterior teeth;—Cuspid, 2nd and 3rd Molars.
 Plate 16. Index, Two Posterior teeth;—2nd and 3rd Molars.



Figure No. 25. Plates 17-18-19-20.
 Plate 17. Index, Five Posterior teeth;—Cuspid, two Bicuspids, 1st and 2nd Molars.
 Plate 18. Index, Four Posterior teeth;—2 Bicuspids, 1st and 2nd Molars
 Plate 19. Index, Four Posterior teeth;—Cuspid and 1st Bicuspid, 1st and 2nd Molars.
 Plate 20. Index, Four Posterior teeth;—Cuspid and 2nd Bicuspid, 1st and 2nd Molars.

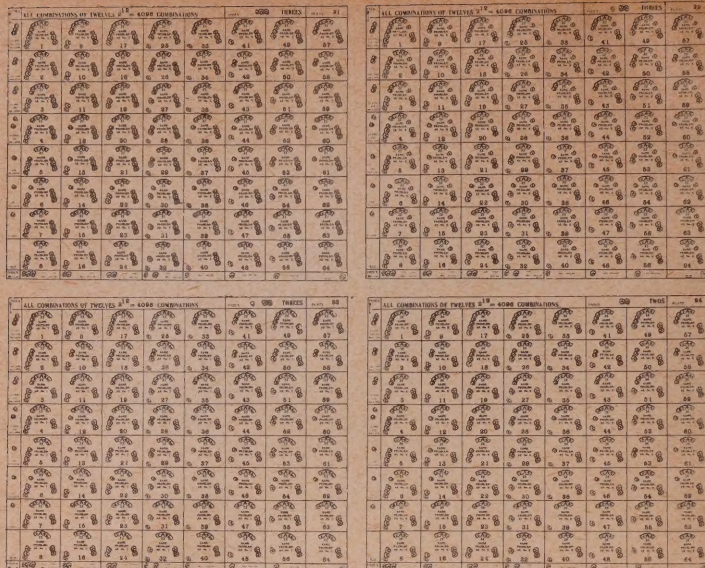


Figure No. 25. Plates 21-22-23-24.

Plate 21. Index, Three Posterior teeth;—2nd Bicuspid, 1st and 2nd Molars.

Plate 22. Index, Three Posterior teeth;—1st Bicuspid 1st and 2nd Molars.

Plate 23. Index, Three Posterior teeth;—Cuspid, 1st and 2nd Molars.

Plate 24. Index, Two Posterior teeth;—1st and 2nd Molars.

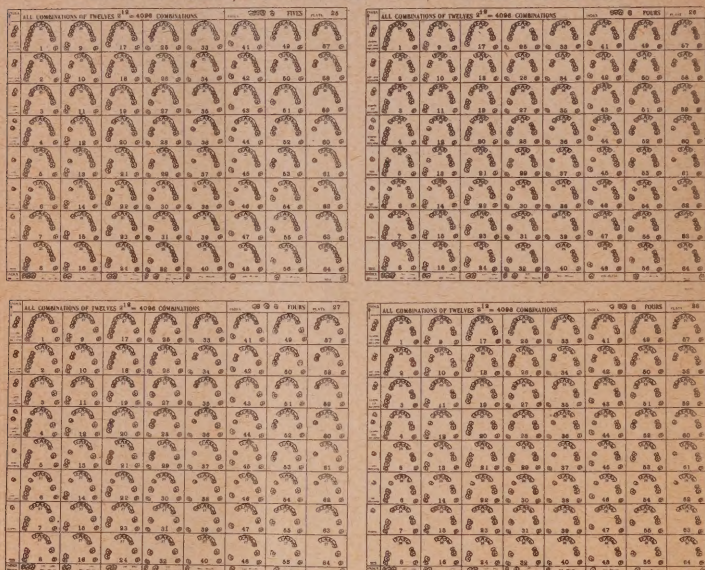


Figure No. 25.

Plates 25-26-27-28.

Plate 25. Index, Five Posterior teeth;—Cuspid, two Bicuspids, 1st and 3rd Molars.

Plate 26. Index, Four Posterior teeth;—2 Bicuspids, 1st and 3rd Molars.

Plate 27. Index, Four Posterior teeth;—Cuspid, 1st Bicuspid, 1st and 3rd Molars.

Plate 28. Index, Four Posterior teeth;—Cuspid, 2nd Bicuspid, 1st and 3rd Molars.

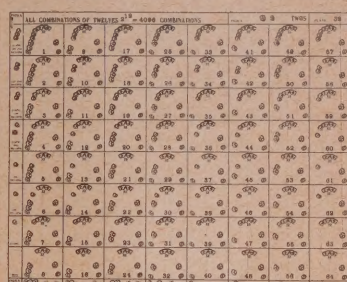
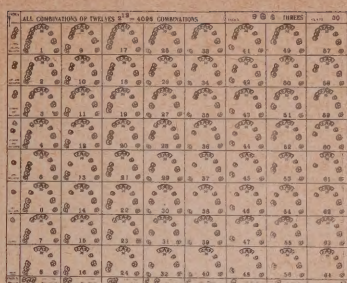


Figure No. 25. Plates 29-30-31-32.

Plate 29. Index, Three Posterior teeth;—2nd Bicuspid, 1st and 3rd Molars.

Plate 30. Index, Three Posterior teeth;—1st Bicuspid, 1st and 3rd Molars.

Plate 31. Index, Three Posterior teeth;—Cuspid, 1st and 3rd Molars.

Plate 32. Index, Two Posterior teeth;—1st and 3rd Molars.

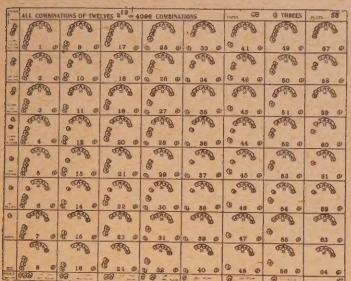
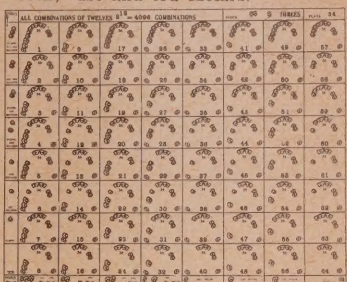
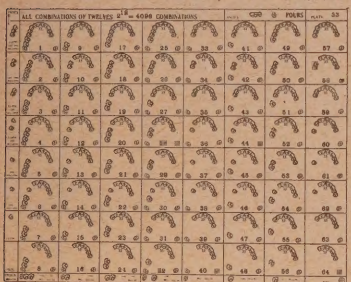


Figure No. 25. Plates 33-34-35-36.

Plate 33. Index, Four Posterior teeth;—Cuspid, 2 Bicuspids, 3rd Molar.

Plate 34. Index, Three Posterior teeth;—2 Bicuspids, 3rd Molar.

Plate 35. Index, Three Posterior teeth;—Cuspid, 1st Bicuspid, 3rd Molar.

Plate 36. Index, Three Posterior teeth;—Cuspid, 2nd Bicuspid, 3rd Molar.

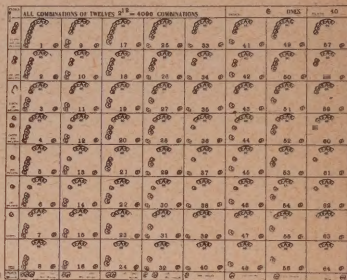
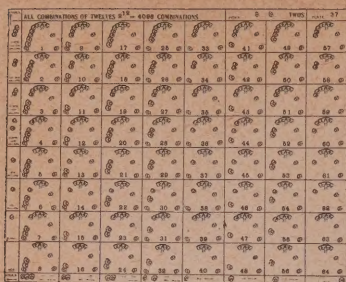


Figure No. 25. Plates 37-38-39-40.
 Plate 37. Index, Two Posterior teeth;—2nd Bicuspid, 3rd Molar.
 Plate 38. Index, Two Posterior teeth;—1st Bicuspid, 3rd Molar.
 Plate 39. Index, Two Posterior teeth;—Cuspid, 3rd Molar.
 Plate 40. Index, One Posterior tooth;—3rd Molar.

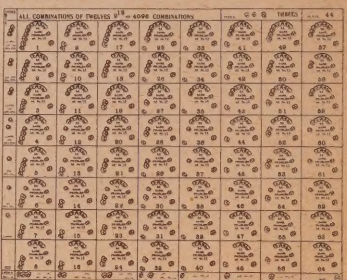
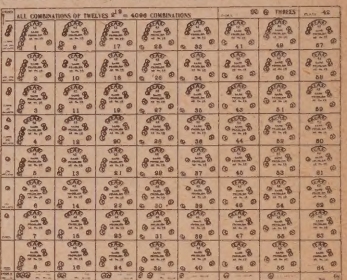
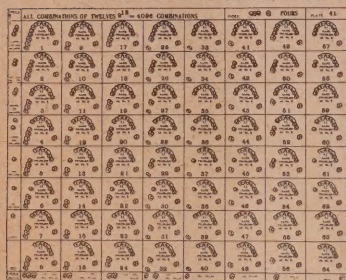


Figure No. 25. Plates 41-42-43-44.
 Plate 41. Index, Four Posterior teeth;—Cuspid, 2 Bicuspids, 2nd Molar.
 Plate 42. Index, Three Posterior teeth;—2 Bicuspids, 2nd Molar.
 Plate 43. Index, Three Posterior teeth;—Cuspid, 1st Bicuspid, 2nd Molar.
 Plate 44. Index, Three Posterior teeth;—Cuspid, 2nd Bicuspid, 2nd Molar.

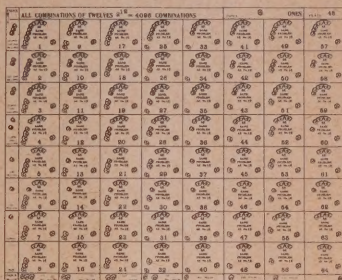
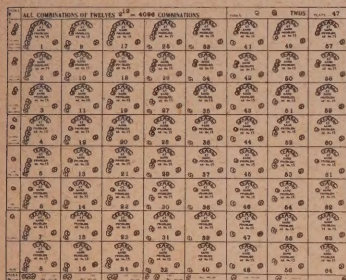
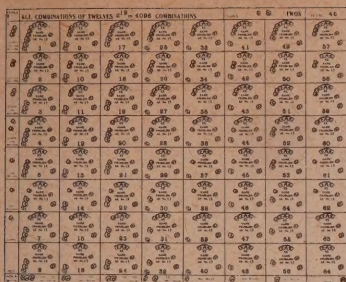


Figure No. 25.

Plates 45-46-47-48.

Plate 45. Index, Two Posterior teeth;—2nd Bicuspid, 2nd Molar.

Plate 46. Index, Two Posterior teeth;—1st Bicuspid, 2nd Molar.

Plate 47. Index, One Posterior tooth;—Cuspid, 2nd Molar.

Plate 48. Index, One Posterior tooth;—2nd Molar.



Figure No. 25.

Plates 49-50-51-52.

Plate 49. Index, Four Posterior teeth;—Cuspid, 2 Bicuspids, 1st Molar.

Plate 50. Index, Three Posterior teeth;—two Bicuspids, 1st Molar.

Plate 51. Index, Three Posterior teeth;—Cuspid, 1st Bicuspid, 1st Molar.

Plate 52. Index, Three Posterior teeth;—Cuspid, 2nd Bicuspid, 1st Molar.

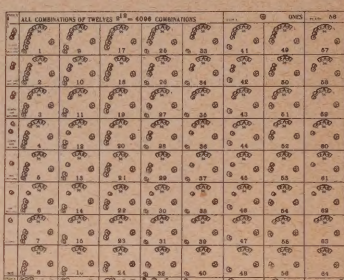
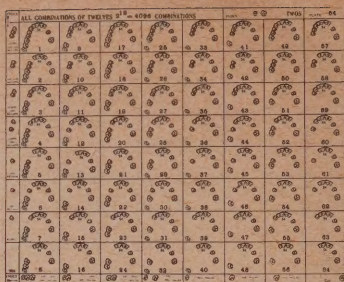


Figure No. 25. Plates 53-54-55-56.
 Plate 53. Index, Two Posterior teeth;—2nd Bicuspid, 1st Molar.
 Plate 54. Index, Two Posterior teeth;—1st Bicuspid, 1st Molar.
 Plate 55. Index, Two Posterior teeth;—Cuspid, 1st Molar.
 Plate 56. Index, One Posterior tooth;—1st Molar.



Figure No. 25. Plates 57-58-59-60.
 Plate 57. Index, Three Posterior teeth;—Cuspid, two Bicuspids.
 Plate 58. Index, Two Posterior teeth;—Two Bicuspids.
 Plate 59. Index, Two Posterior teeth;—Cuspid, 1st Bicuspid.
 Plate 60. Index, Two Posterior teeth;—Cuspid, 2nd Bicuspid.

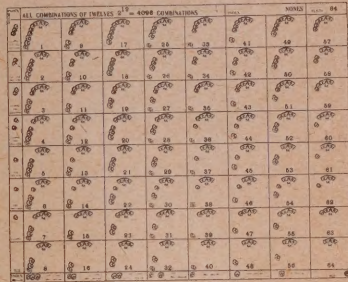
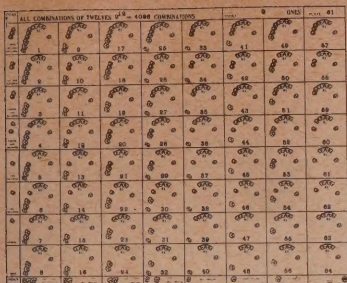


Figure No. 25. Plates 61-62-63-64.
 Plate 61. Index, One Posterior tooth;—2nd Bicuspid.
 Plate 62. Index, One Posterior tooth;—1st Bicuspid.
 Plate 63. Index, One Posterior tooth;—Cuspid.
 Plate 64. Index, No Posterior tooth;—None.

27. THE INDEX FOR 2^{12} COMBINATIONS.

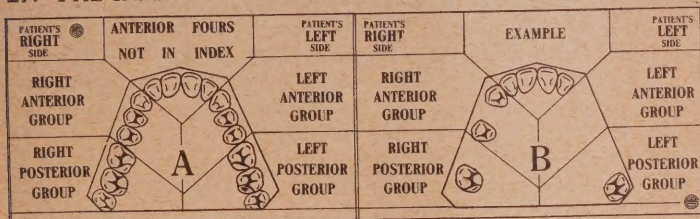


PLATE INDEX FOR COMBINATIONS 2^{12}										PATIENT'S LEFT SIDE	
LEFT POST. SIX	LEFT POST. SIX	LEFT POST. SIX	LEFT POST. SIX	LEFT POST. SIX	LEFT POST. SIX	LEFT POST. SIX	LEFT POST. SIX	LEFT POST. SIX	LEFT POST. SIX	LEFT POST. SIX	LEFT POST. SIX
1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72
73	74	75	76	77	78	79	80	81	82	83	84
85	86	87	88	89	90	91	92	93	94	95	96
97	98	99	100	101	102	103	104	105	106	107	108
109	110	111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130	131	132
133	134	135	136	137	138	139	140	141	142	143	144
145	146	147	148	149	150	151	152	153	154	155	156
157	158	159	160	161	162	163	164	165	166	167	168
169	170	171	172	173	174	175	176	177	178	179	180
181	182	183	184	185	186	187	188	189	190	191	192
193	194	195	196	197	198	199	200	201	202	203	204
205	206	207	208	209	210	211	212	213	214	215	216
217	218	219	220	221	222	223	224	225	226	227	228
229	230	231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250	251	252
253	254	255	256	257	258	259	260	261	262	263	264
265	266	267	268	269	270	271	272	273	274	275	276
277	278	279	280	281	282	283	284	285	286	287	288
289	290	291	292	293	294	295	296	297	298	299	300
301	302	303	304	305	306	307	308	309	310	311	312
313	314	315	316	317	318	319	320	321	322	323	324
325	326	327	328	329	330	331	332	333	334	335	336
337	338	339	340	341	342	343	344	345	346	347	348
349	350	351	352	353	354	355	356	357	358	359	360
361	362	363	364	365	366	367	368	369	370	371	372
373	374	375	376	377	378	379	380	381	382	383	384
385	386	387	388	389	390	391	392	393	394	395	396
397	398	399	400	401	402	403	404	405	406	407	408
409	410	411	412	413	414	415	416	417	418	419	420
421	422	423	424	425	426	427	428	429	430	431	432
433	434	435	436	437	438	439	440	441	442	443	444
445	446	447	448	449	450	451	452	453	454	455	456
457	458	459	460	461	462	463	464	465	466	467	468
469	470	471	472	473	474	475	476	477	478	479	480
481	482	483	484	485	486	487	488	489	490	491	492
493	494	495	496	497	498	499	500	501	502	503	504
505	506	507	508	509	510	511	512	513	514	515	516
517	518	519	520	521	522	523	524	525	526	527	528
529	530	531	532	533	534	535	536	537	538	539	540
541	542	543	544	545	546	547	548	549	550	551	552
553	554	555	556	557	558	559	560	561	562	563	564
565	566	567	568	569	570	571	572	573	574	575	576
577	578	579	580	581	582	583	584	585	586	587	588
589	590	591	592	593	594	595	596	597	598	599	600

ROYAL COLLEGE OF DENTAL SURGEONS

Figure No. 26. The Index for 2^{12} Combinations as Immediately Preceding. The use of this index is described in the text. Note that this index shows the combination of the left posterior six, and is only for the purpose of finding the proper plate, similar to the index for 2^{10} combinations, described, Sec. 24, Fig. 23.

An index has been provided for the foregoing 2^{12} Combinations, by which any of the 4,096 combinations may be readily obtained. The method is, first to divide the case described into four groups, (1) Right anterior, (2) Right posterior, (3) Left anterior, and (4) Left posterior as noted Fig. 26, Sec. A. The patient's left anterior and posterior groups serve as an index for locating the proper plate. The right anterior and right posterior groups locate the combination on this plate. The anterior four teeth are sketched in merely to complete the picture, and are not considered in the index.

Using the example found in Fig. 26, Sec. B, it is found that, in the left anterior group no teeth are present, while in the left posterior group the third molar is present. Referring to the index (Fig. 26C) for plate number, the teeth of the left anterior group will be found along the upper horizontal column, marked with a horizontal arrow; while the teeth of the left posterior group will be found in the vertical column at the extreme right of the diagram, marked with a vertical arrow. Searching along the horizontal column, the nines are located, and the left index finger placed thereon. Searching along the vertical column on the extreme right, the upper third molar is located among the ones, the fourth space from the bottom, and the right index finger is placed thereon. The fingers are caused to move together at right angles, and they will meet on square No. 40, which is the plate number. This plate is then located (Fig. 25, Plate 40), and the index finger of the left hand is placed over the cuspid and second bicuspid (as in the right anterior group of the example) on the left hand index column (fourth space from the top), while the right hand index finger is placed on the second molar (as found in the right posterior group of the example), which is the third space from the end, on the lower horizontal index column; the fingers are caused to travel together at right angles, meeting in combination 44, Plate 40, which is the combination desired. Any combination may be found in like manner by this process, which is similar to that described Sec. 24, with accompanying Fig 23, for 2^{10} combinations.

28. A METHOD OF VIEWING 2^{16} COMBINATIONS OF TEETH (65,536).

It being impossible, in an article of this compass, to make a permanent record of the entire combinations of the sixteen teeth* in either the upper or lower jaw (because there are 65,536 combinations in all in each jaw), a method of viewing the entire number is herewith submitted.

From Fig. 20 two photographic enlargements of $1\frac{1}{2}$ diameters are made. Take one of these enlargements, and clip the index off with the shears.** The remainder of the enlargement is divided into 256

*See article "Partial Denture Mathematics"—ORAL HEALTH, December, 1920, and DENTAL SUMMARY, February, 1921.

**For description of index see legend under Figure 20.

pieces. Each piece is then cut into three parts. First make a straight cut in the median line, and then divert the cut so as to miss the number, as shown Fig. 27A. Then cut out the number. Preserve the observer's right half, and the number, discarding the other part.

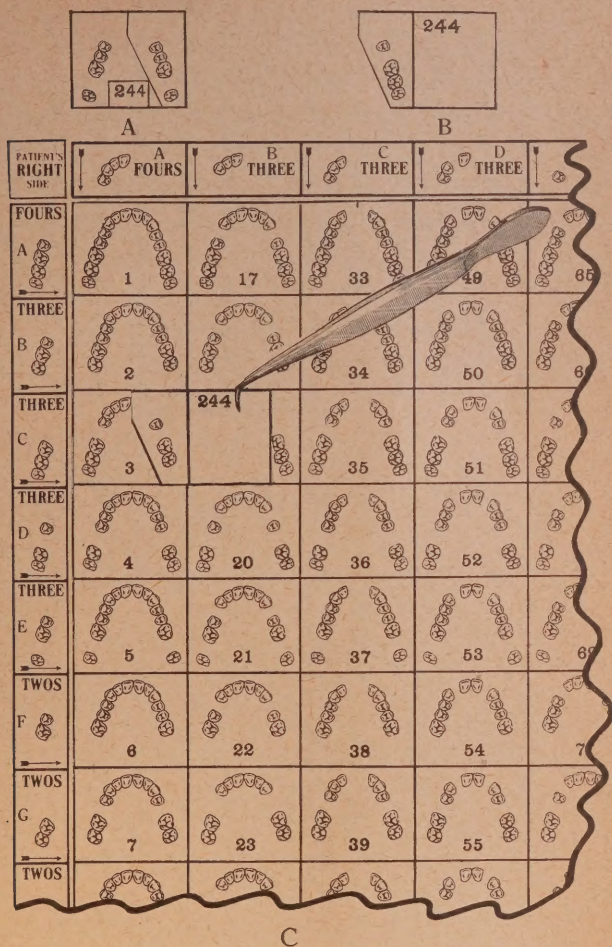
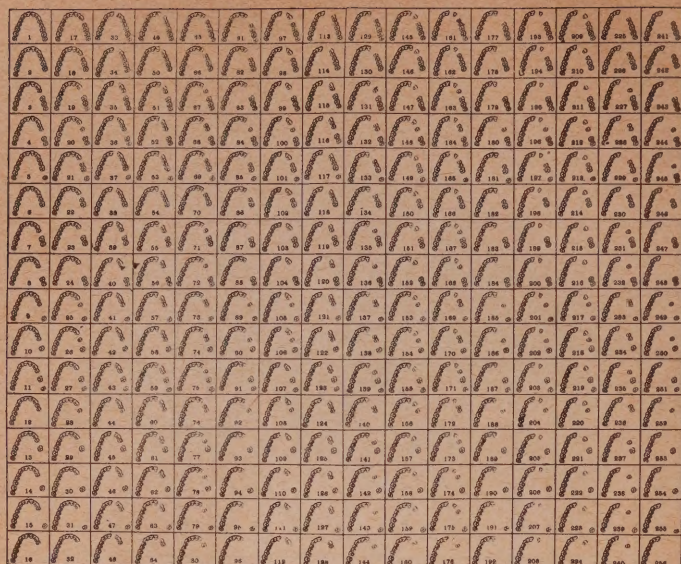


Figure No. 27. Details of a method of viewing 2^{16} Combinations, as described in text, Sec. 28. A. one of the 256 squares of the first photographic enlargement with lines for cutting. B. one of the 256 squares of the photographic enlargement mounted on Bristol board ready for viewing. C. mounted square No. 244 held in pliers and applied to the third of the 256 squares on the second photographic enlargement. It will be seen that the above is only part of Fig. 20.

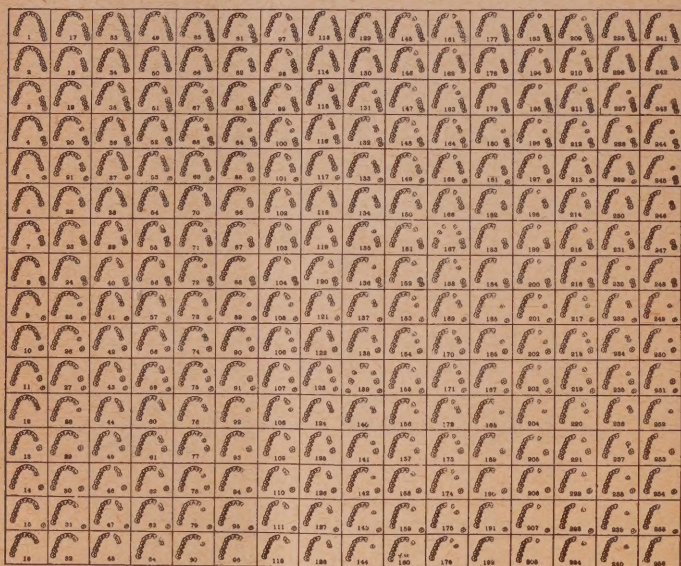


Royal College of Dental Surgeons,

COMBINATIONS OF NATURAL TEETH (Two Factors)

Page 1

Figure No. 28A.



Royal College of Dental Surgeons,

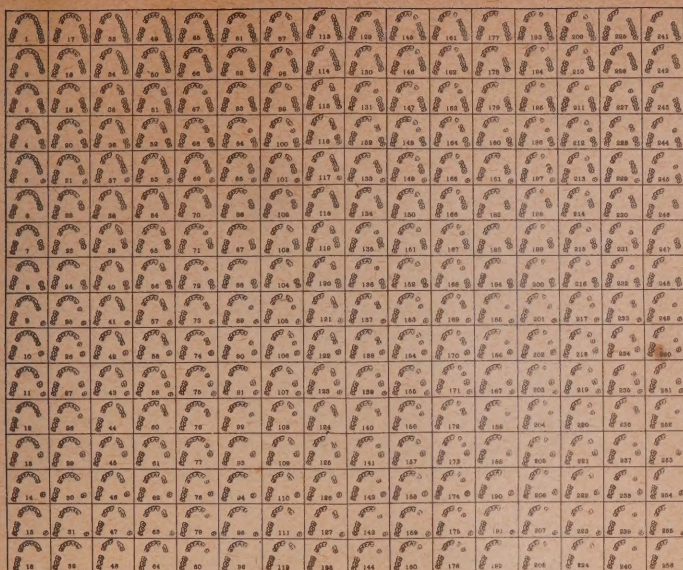
COMBINATIONS OF NATURAL TEETH (Two Factors)

Page 2

Figure No. 28B.

Figure No. 23. A. B. C. D. This illustrates in a permanent form the results we obtained by successively applying the Bristol Board as described in Sec. 23 with accompanying Fig. 27. So far, over one hundred of the 256 permanent charts have been made in the Royal College of Dental Surgeons, Toronto.

Figure 28A. represents the pictures obtained by the application of Bristol board No. 1 to the second photographic enlargement.

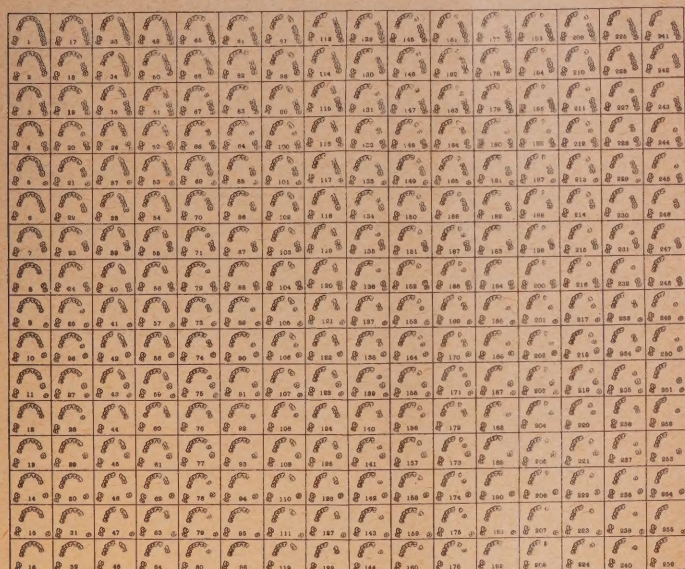


Royal College of Dental Surgeons,

COMBINATIONS OF NATURAL TEETH (Two Factors)

Folio 3

Figure No. 28C.



Royal College of Dental Surgeons,

COMBINATIONS OF NATURAL TEETH (Two Factors)

Folio 4

Figure No. 28D.

Figure 28B. represents the pictures obtained by the application of Bristol board No. 2 to the second photographic enlargement.

Figure 28C represents the pictures obtained by the application of Bristol board No. 3 to the second photographic enlargement.

Figure 28D. represents the pictures obtained by the application of Bristol board No. 4 to the second photographic enlargement.

The next step is to cut out, or obtain from a printer, 256 pieces of Bristol board as wide, and half again as long as the size of one of the 256 pieces into which the enlargement was divided. Upon these paste the parts retained, trimming the Bristol boards as shown, Fig. 27B.

The application is as follows:—Take the uncut enlargement and apply to it Bristol board No. 1 so that it covers one-half of diagram No. 1.* This shows the first combination. Then apply the Bristol board, in like manner, to diagram No. 2. This shows the second combination. The application of the Bristol board to diagram No. 3 will show the third combination, and so on throughout the remainder of the 256 diagrams. We have now viewed 256 combinations of the 65,536.

After applying Bristol board No. 1 to all of the 256 parts, take Bristol board No. 2 and apply it in like manner to the 256 diagrams. We have now viewed another 256 combinations, or a total of 512 combinations of the 65,536.

In like manner apply successively the remaining Bristol boards, and we have then viewed the total 65,536 combinations.

In the foregoing it will be noted that we have only been considering the combinations of the upper teeth. In like manner we can view the combinations of the lower teeth from photographic enlargements of Fig. 21.

29. INTERNAL RELATIONSHIPS FOUND IN THE 2^{16} DENTAL COMBINATIONS.

The internal relationships found in the 2^{16} Dental Combinations are of interest, for they have practical uses in research study.

Because of the fact that the dental arch (containing sixteen teeth) is bilateral, if it be divided in half, there are similar teeth on both the right and left side, hence it follows that every combination on the right side must have a counterpart on the left side. This counterpart is called a *Reverse*. Examples of given combinations and their reverses will be found Fig. 24, as well as in Fig. 29, Nos. 1-9; these contain 16-15-14-13-12-11-10-9 and 8 teeth respectively.

Besides this relationship, there is another and different relationship. For each combination in the 2^{16} Chart, there is another combination which is *Inverse* to it; that is to say, the case where all teeth are *present* but one (for example, the first upper left molar as in space No. 2 Fig. 29). The inverse condition is that in which all the teeth are *absent* but one (for example, the upper first left molar as in space No. 2B Fig. 29). In other words, in a given combination of teeth, the teeth which are present in one case are absent in the *Inverse*.

*The application may be more readily made with pliers, as shown Fig. 27C.

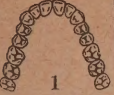
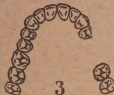
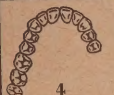
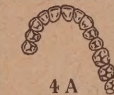
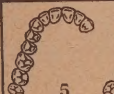
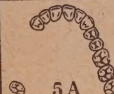
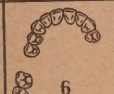
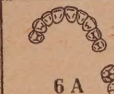
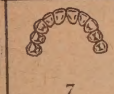
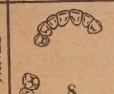
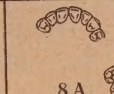
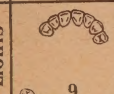
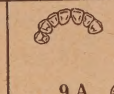
EXAMPLES OF SYMMETRICAL AND UNSYMMETRICAL COMBINATIONS						
	GIVEN COMBINATION	REVERSE		INVERSE	REVERSE INVERSE	
SIXTEENS	 1	 1 A	SYMMETRICAL	NONE 1 B	NONE 1 C	NONES
FIFTEENS	 2	 2 A		 2 B	 2 C	ONES
FOURTEENS	 3	 3 A		 3 B	 3 C	TWOS
THIRTEENS	 4	 4 A		 4 B	 4 C	THREES
TWELVES	 5	 5 A		 5 B	 5 C	FOURS
ELEVENS	 6	 6 A		 6 B	 6 C	FIVES
TENS	 7	 7 A	SYMMETRICAL	 7 B	 7 C	SIXES
NINES	 8	 8 A		 8 B	 8 C	SEVENS
EIGHTS	 9	 9 A		 9 B	 9 C	EIGHTS

Figure No. 29.

Figure 29 contains nine Given Combinations with Reverses, Inverses, and Reverse-Inverse Combinations. It is to be noted that the terms Reverse, Inverse, and Reverse-Inverse, are used in relation to the given combination in column one. An account of these relationships will be found in the text. Note Nos. 2-3-4-5-6-8-9- are unsymmetrical combinations, while 1 and 7 are symmetrical combinations. In the first column, under the caption "Given Combinations", are sample cases, containing teeth present; in the second column, under the caption of "Reverse," is where the same tooth or teeth are present on the opposite side.

In the third column, the word "Symmetrical" is used opposite those cases where the same tooth or teeth are present on the right and left sides.

The fourth column, under the caption of "Inverse," is explained in detail in the text. The fifth column, under the caption of "Reverse-inverse," is also explained in detail in the text.

In addition to Reverse, and Inverse, column five under the caption of *Reverse-inverse* is simply the Inverse of column two.

In addition to these, each Reverse combination has its Inverse; so that, to sum up, for every combination in the 2^{16} Chart, except the symmetrical combinations, will be found a relationship with three others, namely, Reverse, Inverse, and Reverse-inverse. In Fig. 29, these are opposite to the given combinations numbered 1 to 9. An analysis of the total number of these is given in Fig. 30.

RELATIONSHIP ANALYSIS OF 2^{16} OR 65536 DENTAL COMBINATIONS					
ROYAL COLLEGE OF DENTAL SURGEONS					
IN GROUP OF COMBINATIONS OF	WITH TOTAL COMBINATIONS	THERE ARE UNSYMMETRICAL GIVEN COMBINATIONS	AND SYMMETRICAL COMBINATIONS	REVERSE UNSYMMETRICAL COMBINATIONS	WITH
SIXTEENS	1	0	1	0	
FIFTEENS	16	8	0	8	
FOURTEENS	120	56	8	56	
THIRTEENS	560	280	0	280	
TWELVES	1820	896	28	896	
ELEVENS	4368	2184	0	2184	
TENS	8008	3976	56	3976	
NINES	11440	5720	0	5720	
		3200	35	3200	
		TOTAL 16320	TOTAL 128	TOTAL 16320	
		REVERSE UNSYMMETRICAL COMBINATIONS	INVERSE SYMMETRICAL COMBINATIONS	INVERSE UNSYMMETRICAL COMBINATIONS	
EIGHTS	12870	3200	35	3200	
		5720	0	5720	
SEVENS	11440	3976	56	3976	
SIXES	8008	2184	0	2184	
FIVES	4368	896	28	896	
FOURS	1820	280	0	280	
THREES	560	56	8	56	
TWOS	120	8	0	8	
ONES	16	0	1	0	
NONES	1	0	1	0	
	TOTAL 65536	TOTAL 16320	TOTAL 128	TOTAL 16320	

A.

RECAPITULATION		65536 DENTAL COMBINATIONS	
		ROYAL COLLEGE OF DENTAL SURGEONS	
16320			16320
GIVEN	128 GIVEN		REVERSE
UNSYMMETRICAL	SYMMETRICAL		UNSYMMETRICAL
COMBINATIONS	COMBINATIONS		COMBINATIONS
16320	128 INVERSE		16320
INVERSE	SYMMETRICAL		REVERSE INVERSE
UNSYMMETRICAL	COMBINATIONS		UNSYMMETRICAL
COMBINATIONS			COMBINATIONS

B.

Figure No. 30. An analysis of the relationships in the 2^{16} Charts, Upper and Lower.

In the above Chart, Figure 30, an effort is made to analyse the relationships (as instanced in Fig. 29), as they occur in the 2^{16} or 65,536 combinations of the upper or lower teeth.

Also in the 2^{16} Charts (Upper Fig. 20, and Lower Fig. 21) there are 256 symmetrical combinations as shown. Symmetrical combinations are those in which the teeth present and missing are the same on both right and left sides. One-half of the 256 symmetrical combinations (128 in number) are Inverses of the other half of the symmetrical combinations.

It will be noted also that both the given symmetrical combinations and their reverses are identical. It will also be noted that the Inverse combination of a given symmetrical combination, is always identical with the Reverse-inverse of that combination. Two examples of this may be noted, Fig. 29, Nos. 1 and 7.

So it will be noted, in Fig. 29, that there is a relationship between any given unsymmetrical dental combination of the 2^{16} combinations of teeth, namely, Given Combinations, Reverse Combinations, Inverse Combinations, and Reverse-inverse Combinations. It will also be remembered, that the Symmetrical Combinations show an Inverse only, because any Given Symmetrical Combination and its Reverse is the same. The foregoing Chart Fig. 30, A, outlines the number of these combinations in each group of sixteens, fifteens, etc., to the nones.

The process of reading off the numbers of Reverses, Inverses, and Reverse-Inverses is to begin at the left with the desired group of combinations, as shown under the heavy arrow at the upper left hand corner of Fig. 30 A, and follow across to the arrows at the extreme right of the Chart. Then follow the course that particular arrow, as it leads back again to the combinations on the lower half of the Chart.

As an explanatory example of the above, let us choose the group of fifteens. It will then read:

In GROUP OF COMBINATIONS of fifteen, WITH TOTAL COMBINATIONS of sixteen, THERE ARE eight UNSYMMETRICAL GIVEN COMBINATIONS, no SYMMETRICAL COMBINATIONS, and eight REVERSE UNSYMMETRICAL COMBINATIONS with (here follow down arrow) eight INVERSE UNSYMMETRICAL COMBINATIONS, no INVERSE SYMMETRICAL COMBINATIONS, and eight REVERSE-INVERSE UNSYMMETRICAL COMBINATIONS.

The components of any other groups may be found in like manner, Fig. 30 B is a graphic recapitulation of the above, showing, 16,320 each of Given Combinations, Reverses, Inverses, and Reverse-inverse, and including 128 Symmetrical Combinations, and 128 Reverses of these, totally 65,536 or 2^{16} .

30. THE RECAPITULATION OF THE GROUPS OF COMBINATIONS IN VARIOUS POWERS.

COMBINATIONS		COMBINATIONS IN GROUPS																ROYAL COLLEGE OF DENTAL SURGEONS		COMBINATIONS	
		2 ¹	2 ²	2 ³	2 ⁴	2 ⁵	2 ⁶	2 ⁷	2 ⁸	2 ⁹	2 ¹⁰	2 ¹¹	2 ¹²	2 ¹³	2 ¹⁴	2 ¹⁵	2 ¹⁶				
NONES	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	NONES		
ONES			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	ONES		
TWOS				1	3	6	10	15	21	28	36	45	55	66	78	91	105	120	TWOS		
THREES					1	4	10	20	35	56	84	120	165	220	286	364	455	560	THREES		
FOURS						1	5	15	35	70	126	210	330	495	715	1001	1365	1820	FOURS		
FIVES							1	6	21	56	126	232	362	572	828	1202	1653	2184	FIVES		
SIXES								1	7	28	84	210	462	924	1716	3003	5005	8008	SIXES		
SEVENS									1	8	36	120	330	792	1716	3432	6435	11440	SEVENS		
EIGHTS										1	9	45	165	495	1287	3003	6435	12870	EIGHTS		
NINES											1	10	55	220	715	2002	5005	11440	NINES		
TENS												1	11	66	286	1001	3003	8008	TENS		
ELEVENS													1	12	78	364	1365	4368	ELEVENS		
TWELVES														1	13	91	455	1820	TWELVES		
THIRTEENS															1	14	105	560	THIRTEENS		
FOURTEENS																1	15	120	FOURTEENS		
FIFTEENS																	1	16	FIFTEENS		
SIXTEENS																		1	SIXTEENS		
TOTAL COMBINATIONS	1	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768	65536				

Figure No. 31. A Recapitulation of the various groups of Combinations of each power, from 2¹ to 2¹⁶ with total Combinations in each case.

The use of this chart is for finding the number of groups of nones, ones, twos, threes, etc., in any given power, and is as follows:—

(1) The power, or index, is the number of persons, places, or things, to be considered (from 2¹-2¹⁶). The power desired is found in the upper horizontal column.

(2) Reading downward under the power desired, will be found the different groups of nones, ones, twos, threes, etc. The designations of nones, ones, twos, threes, etc., are placed on each side of the chart for the sake of convenience in reading.

(3) At the bottom of each vertical column will be found the total of the different combinations under each power.

An example, take 2⁷. Under this caption found the numbers 1-7-21-35, -35-21-7-1, making a total of 128 different combinations as shown at the bottom. Taking the first number 1, and passing the finger to the right or left, the word none will be found, meaning that there is one group of nones. Similarly, the second number 7 will have opposite to it the word ones, meaning that there are seven groups of ones. The remaining designation of the groups namely, 21-35-35-21-7-1 may be similarly found. The groups of any other power in this chart may be also similarly found.

In Master Charts 2¹ to 2⁸, as presented in Figs. 2-3-4-5-8A-10-16-17, the total number of combinations (of nones, ones, twos, threes, fours, etc.) is indicated on the lower right hand corner of each Master Chart. The number of combinations of nones, ones, twos, threes, fours, etc., is not totalled separately, but may be counted by the reader on the charts.

In this study of the powers of combinations, only the Master Charts 2¹ to 2⁸ are given in the text, but in Fig. 31 the number of combinations is given from 2¹ to 2¹⁶.

31. MASTER CHARTS 2⁹ TO 2¹⁶, NOT FOUND IN THIS SERIES.

Should it be desired to substitute persons, places, or things, for Master Charts 2⁹ to 2¹⁶, not found in this series, there are two methods.

The first method is used in the case of 2¹⁰, 2¹² and 2¹⁶, numbering

1024, 4096, and 65,536 respectively. These combinations may be viewed in their entirety in the text, Figs. 22, 25, and 27. If we consider the combinations of ten things (2^{10}) twelve things (2^{12}) or sixteen things (2^{16}), instead of substituting for letters of the alphabet as in the Master Charts 2^1 to 2^8 , all that is necessary is to substitute the things for the teeth as shown. For example using Fig. 22 as a Master Chart, the combination of ten things are to be considered:—Substitute the first thing for the third molar tooth, the second thing for the second molar tooth, the third thing for the first molar tooth;—and so forth. Then by referring to Fig. 22, the various combinations may be read off directly from the combinations of teeth as shown. This may be done in a similar manner with twelve or sixteen things from Figs. 25 and 27.

The second method is to make new Master Charts, as indicated in section 32, and the accompanying Fig. 32.

TO BUILD ADDITIONAL COMBINATIONS				
FOR				
2^5	GROUP	2^2 WITH	$2^3 = 2^5$	32
2^6	..	2^3 ..	$2^3 = 2^6$	64
2^7	..	2^3 ..	$2^4 = 2^7$	128
2^8	..	2^4 ..	$2^4 = 2^8$	256
2^9	..	2^4 ..	$2^5 = 2^9$	512
2^{10}	..	2^5 ..	$2^5 = 2^{10}$	1024
2^{11}	..	2^5 ..	$2^6 = 2^{11}$	2048
2^{12}	..	2^6 ..	$2^6 = 2^{12}$	4096
2^{13}	..	2^6 ..	$2^7 = 2^{13}$	8192
2^{14}	..	2^7 ..	$2^7 = 2^{14}$	16384
2^{15}	..	2^7 ..	$2^8 = 2^{15}$	32768
2^{16}	..	2^8 ..	$2^8 = 2^{16}$	65536

Figure No. 32. A scheme of juxtaposition for developing Master Charts up to 2^{16} . For details see text.

32. DEVELOPING MASTER CHARTS 2^9 - 2^{10} - 2^{11} - AND UP.

This may be done following the method of juxtaposition fully described in section 14. A table of suitable lower powers to form the higher powers, as described in section 14, will be noted in Fig. 32.

33. COMBINATIONS OF THREE CONDITIONS AS 3^1 , 3^2 , 3^3 , ETC.

Occasionally it may be necessary to study objects as affected by three conditions. Considering teeth, for an example, the conditions may be (1) present, (2) absent, (3) present but pulpless. This third condition changes the integer from 2 to 3 and greatly complicates

the problem. At the present time the writer has not encountered the necessity of developing combinations of three conditions.

The difference in the number of combinations formed by six teeth with two conditions (1, present;- and 2, absent) and the combinations of six teeth with three conditions (1, present;- 2, absent;- and 3, present and pulpless) is noteworthy. The combinations of six teeth with two conditions is 2^6 , amounting to 64 combinations. The combinations of six teeth with three conditions is 3^6 , amounting to 729 combinations, over eleven times as many.

Also note that, the difference of sixteen teeth under two conditions is 2^{16} , or 65,536; and under three conditions, is 3^{16} , which amounts to 43,046,721, over 656 times as much.

Hence the integer of a third condition complicates the problem so as to become unwieldy, and, in the experience of the writer, may be overcome in other ways, such as the consideration of the third variation of each individual case. At a matter of interest, below will be found the different totals, powers of the integers 2 and 3, up to the sixteenth power.

$2^1 = 2$	$3^1 = 3$
$2^2 = 4$	$3^2 = 9$
$2^3 = 8$	$3^3 = 27$
$2^4 = 16$	$3^4 = 81$
$2^5 = 32$	$3^5 = 243$
$2^6 = 64$	$3^6 = 729$
$2^7 = 128$	$3^7 = 2,187$
$2^8 = 256$	$3^8 = 6,561$
$2^9 = 512$	$3^9 = 19,683$
$2^{10} = 1,024$	$3^{10} = 59,049$
$2^{11} = 2,048$	$3^{11} = 177,147$
$2^{12} = 4,096$	$3^{12} = 531,441$
$2^{13} = 8,192$	$3^{13} = 1,594,323$
$2^{14} = 16,384$	$3^{14} = 4,782,969$
$2^{15} = 32,768$	$3^{15} = 14,348,907$
$2^{16} = 65,536$	$3^{16} = 43,046,721$

34. USES OF COMBINATIONS IN APPLIED MECHANICS.

In the field of applied mechanics the use of combinations, as described in the foregoing text, is of value; and perhaps one of the most common examples, is that of the pin tumbler cylinder lock, as found in the front door of the majority of dental offices. The turning plug, which opens the lock, is released when the five pins, in Figure 33 A, and B, are brought to a level of the periphery of the turning plug, as at Fig. 33 C, which releases the turning plug, as at 33 D.

It is estimated that, within a range of $\frac{1}{4}$ of an inch (the divisible part of the pin), 125 different divisions may be made. Thus for each pin, the combinations would be 125; or in other words, if the pin tumbler lock had only one pin, there would be 125 different combinations, each requiring a separate key, and with each additional pin the number increases 125 times. For two pins, we would have the formula of 125^2 ; for three pins, 125^3 ; and for five pins we would have a formula of 125^5 , or 29, 515, 343, 125 combinations. This, it must be admitted, provides fairly well against the opening of a lock by any other key than the one provided.

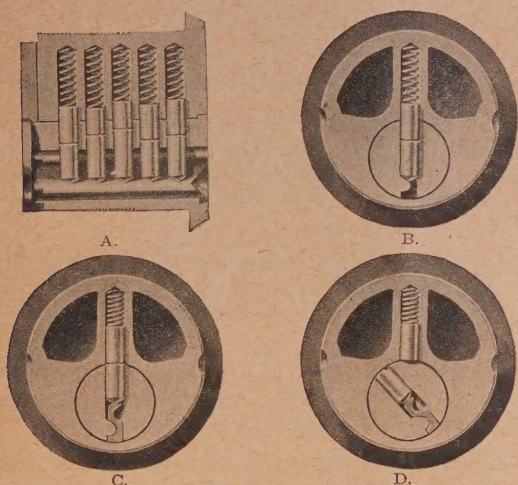


Figure 33. An example of Combinations, in Applied Mechanics;— The Pin Tumbler mechanism in high grade locks, padlocks, etc. Courtesy of Yale and Towne Mfg. Co., Stamford, Conn.

- A.—Longitudinal section of the mechanism of Yale pin-tumbler cylinder as on padlocks and door locks. Note five pins, the divisions of which lie below the turning plug, and which divisions range about $\frac{1}{4}$ -inch in the length of the pin.
- B.—Transverse section through the cylinder and plug shown at A.
- C.—With key inserted the divisions of the five pins coincide with the periphery of the turning plug which,
- D.—Allows the plug to turn as shown.

35. CONCLUSION.

The foregoing is submitted with the hope that the more imaginative research minds in dentistry will find uses for this system. While the Engineering side of Dentistry, particularly Prosthetic Dentistry, can never be reduced to an exact science because of biological factors ever present, yet, beyond a doubt, standardization, in which the study of combinations plays an important part, will mean much in the efforts to realize better dentistry.

The Canadian Dental Research Foundation

is the official Research Organization of the Dental Profession in the Dominion of Canada, two Directors being appointed by the Dental Board of each Province and two Directors appointed, ex-officio, by virtue of their office in the Canadian Dental Association.

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Studies in Periodontal Pathology

Harold Keith Box, D.D.S., Ph.D., F.A.A.P.

Royal College of Dental Surgeons of Ontario
TORONTO

Including Study Upon
The Mechanics of Occlusion

By G. R. Anderson, B.A.Sc., M.A.

*Professor of Engineering Physics, University
of Toronto, and Professor of Physics, Royal
College of Dental Surgeons of Ontario, Toronto*

and a

Summary of the Signs of In-
cipient Periodontal Disease

By Harold Keith Box

Bulletin Number Seven

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Studies in Periodontal Pathology

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INTRODUCTION

NO adequate understanding of periodontal pathology can be attained except through a comprehension of the correlation which exists between structure and function. In arriving at a broad conception of the subject as a whole, the functions of the teeth and their supporting structures form the basis for the interpretation of the information gained through research in the field of the normal and pathologic anatomy of these regions. In other words, the study of physiology must go hand in hand with the study of histology and histo-pathology. Histo-pathologic research, as is to be expected, has a most direct and intimate bearing upon the scientific and successful investigation of periodontal disease. And a careful consideration of the findings of the microscope is essential in the formulation of correct theories.

The importance of histo-pathology in the field of periodontia need not be emphasized, as it is a self-evidenced fact that scientific diagnosis must be based upon an appreciation of this science. There is, however, on the part of many scientists, a growing realization that the evidence of the clinic furnishes a contribution to the whole body of knowledge which must also be given consideration. And this holds for periodontology as well as for other fields in science.

In this paper we shall concern ourselves chiefly with the morphologic changes which take place during the development of the lesions commonly found in the periodontal tissues. In presenting the histo-pathology of the periapical together with the gingival and parietal tissues, emphasis is laid on the fact that periodontology must of necessity embrace the consideration of all the tissues which lie in proximity to the tooth. Furthermore, disease inaugurated in one part of the periodontium may, and frequently does, extend to and involve every part of this complex structure. Hence one part of the periodontium must not be viewed to the exclusion of the remainder.

Note: A limited number of Bulletins, covering Dr. Box's previous work on the Dentinal-Cemental Junction and Normal and Pathological Histology of the Dental Pulp, will be supplied upon application.—Canadian Dental Research Foundation.

PART I: NORMAL HISTOLOGY.

A fundamental knowledge of periodontal disease is impossible without an insight into the normal histological characteristics of the tissues in which the pathological changes are initiated and carried on. The following brief description of the minute anatomy of the periodontium, e.g., the gingivae, the pericementum, and the alveolar process, will therefore be in order.

THE GINGIVAE.

The gingivae include all the soft tissues which invest the cervical portions of the crowns and roots of the teeth, to the level of the crests of the alveolar process. The main bulk of the gingival tissues rests upon the crests of the alveolar process and is supported by them. Attached to the cementum, from the level of the alveolar crest to the gingival line, which is marked by the amelo-cemental junction, is the division of these tissues, known as the cemental gingivae. The cemental gingivae are attached to the alveolar crest by fibres of the periosteum and certain principal fibres which are inserted in the cementum.

Rising from the cemental gingivae and supported by them, are wedged-shaped tissue extensions which encircle the enamel at the cervix. These are known as the marginal gingivae. By their contact with the enamel, they form the so-called gingival crevice, the deepest portion of which is bounded by the first attachment of the cemental gingivae at the amelo-cemental junction (fig. 2).

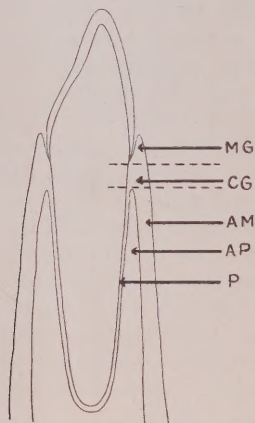


Fig. 1.—Diagrammatic drawing showing the divisions of the periodontal structures.

M G==Marginal gingiva. C G==Cemental gingiva. A M==Alveolar mucosa.
A P==Alveolar process. P==Pericementum,

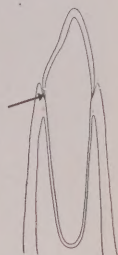
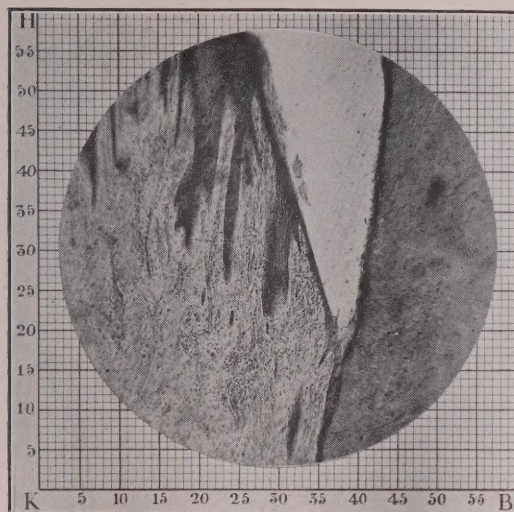


Fig. 2— x 94. Marginal and cemental gingivae, showing the base of the gingival crevice. Note the extremely thin layer of epithelium on the crevicular surface of the marginal gingiva in this specimen. The epithelium is that portion of the marginal gingiva shown in the illustration as very dark in comparison with the connective tissue.

H K 18 x K B 38 (see explanatory note on opposite page), Base of gingival crevice. Tissue above line H K 18 is the marginal gingiva; tissue below this line is the cemental gingiva.

H K 30 x K B 34, Extremely thin layer of crevicular epithelium.

H K 40 x K B 23, Connective tissue papilla.

An explanation of the method of mounting the photographs in this paper may be in order here.

It has long been the practice in plane geometry to locate the position of any point, line or surface, by reference to a system of two fixed lines, usually at right angles to each other, called the axes of coordinates. This is exactly similar to the method of indicating a point on the earth's surface by a statement of its latitude and longitude. These coordinates intersect at a point called the origin, and distances above or below the horizontal or base line are usually denominated ordinates, while distances to one side or the other of the vertical line are termed abscissae.

The common practice of indicating any special point on a photomicrograph by drawing a circle round it or placing a letter close to it is objectionable because it mars the photograph as a whole and quite often obscures something that a reader may wish to see, also it is not always precise. The method of providing a separate skeleton drawing of the photograph and placing the same over or beside the original complicates the reference. For these reasons it was decided to mount the photographs in this article on a coordinate mat so that any point in the photograph could be located by stating its coordinates.

Two lines intersecting at the point K and denominated HK and KB form the axes of reference and lines parallel to these are drawn to the number of 60. This forms the mat upon which all the photographs are mounted. It then becomes an easy matter for the reader to locate any

The name alveolar mucosa is given to the tissue which covers the alveolar process for a variable distance apically. It is continuous with the cemental gingiva.

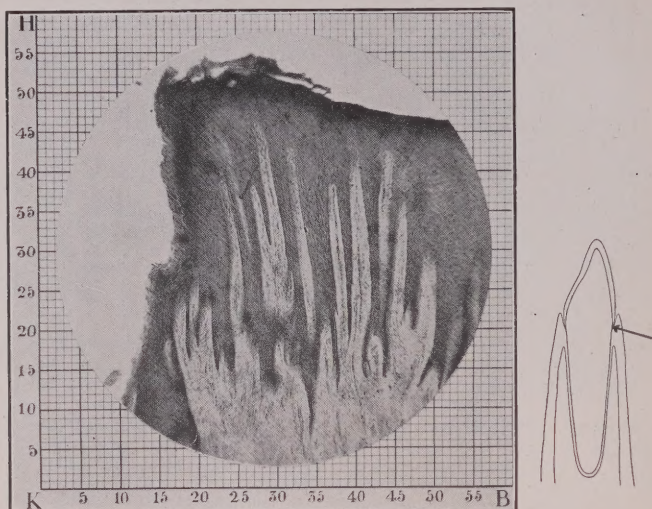


Fig. 3—x 94. Marginal gingiva, showing thick epithelial covering on the crest and external surface: also deep invagination of the epithelium by connective-tissue papillae.

H K 50 x K B 20, Crest of marginal gingiva. Epithelium extends from level of H K 15 to H K 52.

H K 30 x K B 38, Typical connective-tissue papilla.

H K 35 x K B 10, Gingival crevice.

The epithelium which covers the gingivae is of the stratified squamous type, and rests on a thin basement membrane. It differs from that of the alveolar mucosa in that it becomes thicker and stronger progressively from a point approximately opposite the crest of the alveolar process, to the crest of the marginal gingiva. A characteristic of the gingival epithelium is its invagination by finger-like

point referred to in the text by the simple expedient of laying a straight edge across the photograph at the distances indicated.

Professor G. R. Anderson, Professor of Engineering Physics, University of Toronto, and Professor of Physics, Royal College of Dental Surgeons, suggested the possibility of utilizing this system of co-ordinates in the minute description of photomicrographs. He planned and drafted the system used in the accompanying illustrations. Prof. Anderson also made the photomicrographs for each of the papers published in this issue. To this work he brought an intimate and far-reaching knowledge of the physics of light and of photography, and by the perfection of the results thus obtained, has placed the author under a lasting obligation which is hereby gratefully acknowledged.

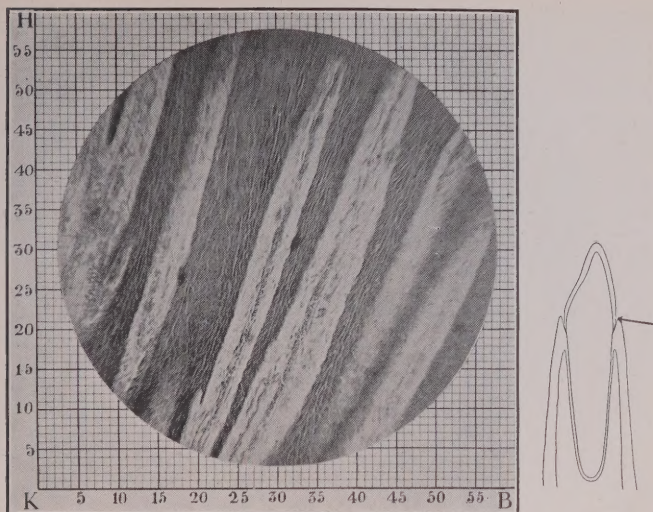


Fig. 4—x 250. Connective-tissue papillae in the epithelium of the marginal and cemental gingivae showing blood-vessels.

H K 53 x K B 38, Tip of one of the papillae.

H K 38 x K B 40, Another connective-tissue papilla.

H K 23 x K B 34, Blood-vessel in papilla.

papillae of connective tissue (fig. 4). The distribution of the epithelium on the crevicular surface of the marginal gingiva is worthy of special note because, as a rule, it is unusually thin. Occasionally breaks can be noticed in this lining, where the epithelium is absent, and again, imperfect junctions of the crevicular epithelium with the cementum are frequently observed. These facts,—its extreme thinness, the possible presence of breaks on the surface and imperfect junctions—render this crevicular surface the weakest link in the chain of the epithelial cordon in the mouth.

The gingivae have an extremely rich blood supply, which is derived from the pericemental and periosteal blood-vessels, as well as from those of the adjoining alveolar mucosa. The connective tissue of each papilla carries an arteriole which passes to its extremity, where it terminates in a capillary loop and returns as a vein (figs. 5 and 6). This circulatory apparatus is designed to carry nourishment to all the epithelial cells. It is frequently seen, in the microscopic study of these tissues, that the cells separating the capillary loops from the external surface, and hence from the mouth flora, are very few in number (figs. 7, 8, 9, 10, 11, 12).

The alveolar mucosa is characterized by a thin epithelium with shallow, invagination by connective tissue papillae, and by a connec-

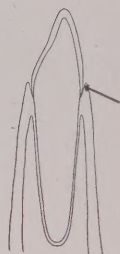
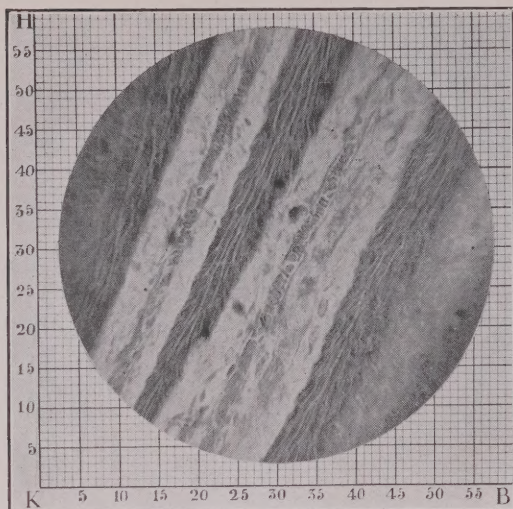


Fig. 5— x 500. Two connective-tissue papillae, showing arteriols and venule. The smaller papilla has a width of 9 (coordinate) lines, the larger has a width of 14 (coordinate) lines.

H K 33 x K B 34, Arteriole. Note the red blood-cells in the arteriole.
H K 33 x K B 37, Venule.

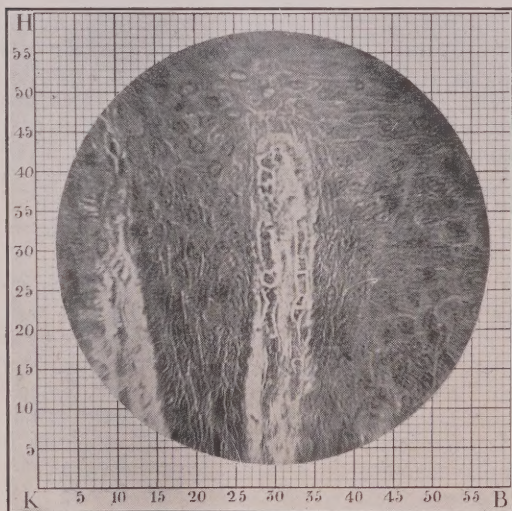


Fig. 6— x 500. Capillary loop at the extremity of the papilla.

H K 44 x K B 31, Capillary loop.

H K 50 x K B 31 Stratified squamous epithelium.

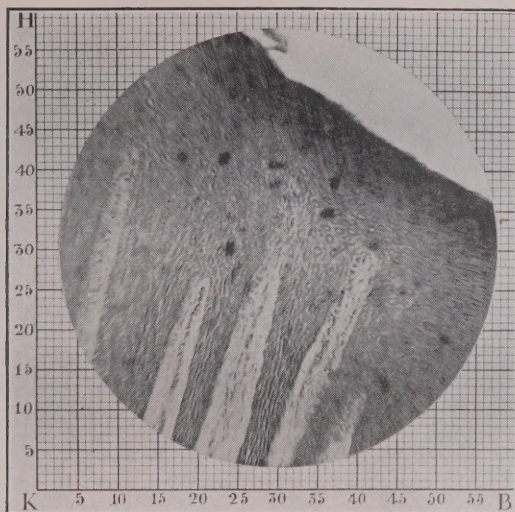


Fig. 7—x 250. External surface of the marginal gingiva, showing proximity of the capillary loops in the papillae, to the surface. The layer of epithelial cells protecting the blood-stream from mouth bacteria is here quite thin.

H K 31 x K B 41, Extremity of papilla, containing capillary loop.

H K 42 x K B 46, External surface of marginal gingiva nearest this point.

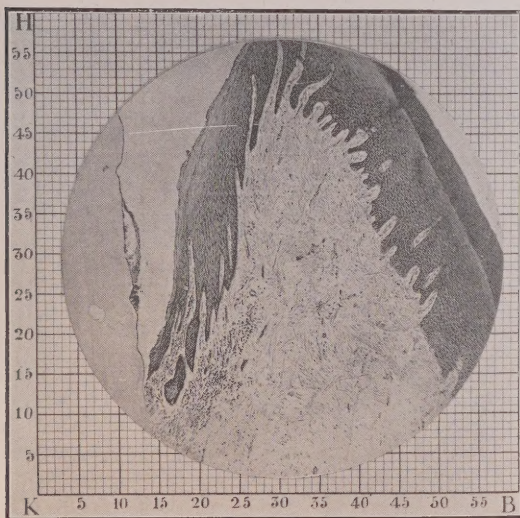


Fig. 8. Faulty junction of the crevicular epithelium with the tooth.

H K 15 x K B 13, Base of gingival crevice. Note lack of epithelial protection of connective tissue of cemental gingiva from the contents of the gingival crevice. Note also small area of leukocytic infiltration in adjacent connective tissue.

H K 40 x K B 13, Gingival crevice.

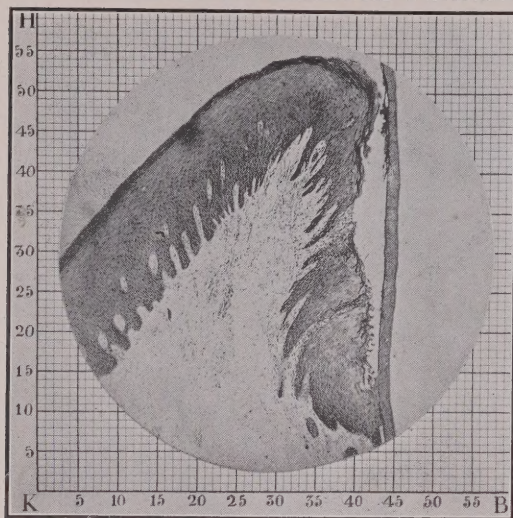


Fig. 9. A break in the crevicular epithelium.

H K 26 x K B 41, Connective tissue of marginal gingiva exposed to the fluids of the gingival crevice.

H K 36 x K B 42, Gingival crevice.

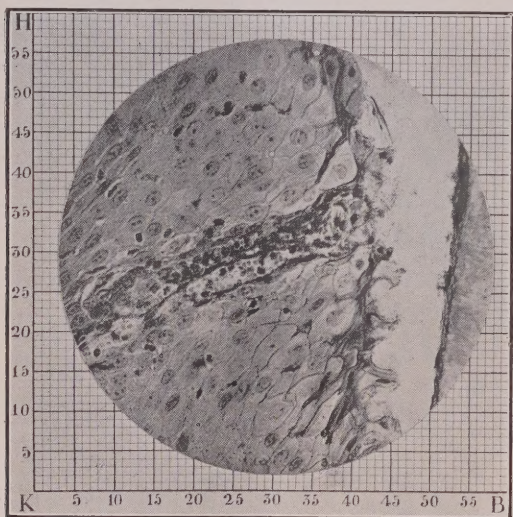


Fig. 10— x 500. High magnification of the break in the crevicular epithelium shown in the previous illustration.

H K 36 x K B 43, Break in epithelium.

H K 30 x K B 23, Blood-vessel in connective tissue. Note that the blood-vessel extends nearly to the crevicular surface.

H K 35 x K B 47, Gingival crevice.

H K 40 x K B 54, Bacteria on surface of tooth.

H K 45 x K B 33, Nucleus of epithelial cell. Note well defined outlines of epithelial cells and of nuclei.

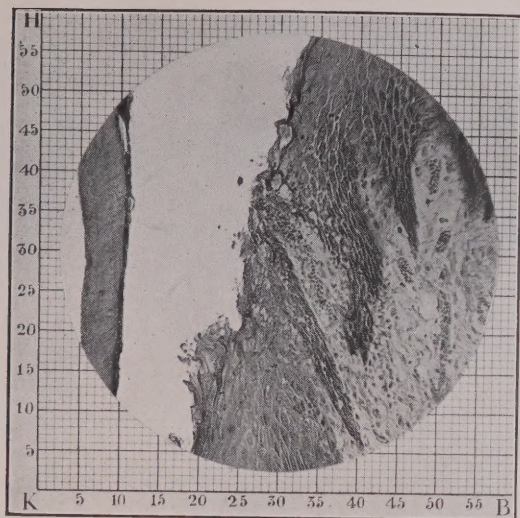


Fig. 11. A break in the epithelium on the crevicular surface. Note the blood-vessel passing to the surface.

H K 37 x K B 27, Break in epithelium.

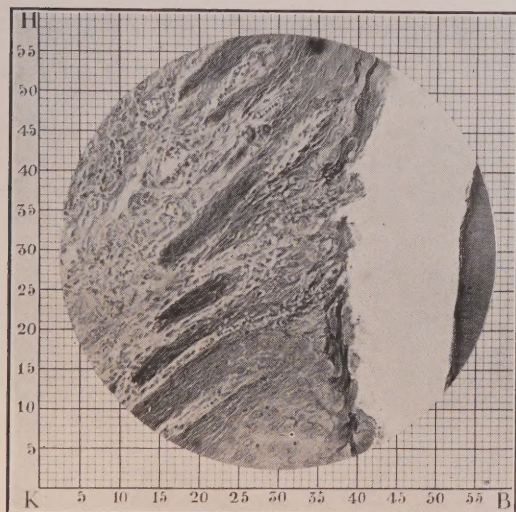


Fig. 12. Group of breaks in the epithelium on the crevicular surface.

H K 42 x K B 40 to H K 25 x K B 39, Total extent of break.

tive tissue which shows a dense interlacing meshwork of fibres of white connective tissue. This latter feature gives to this tissue its comparative immobility (fig. 13).

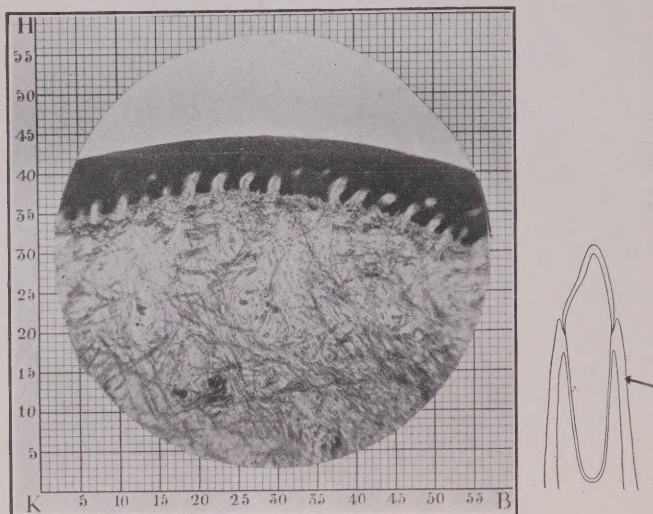


Fig. 13— x 94. Alveolar mucosa, showing comparatively thin epithelium, also the interlacing connective-tissue fibres which bind it to the periosteum.

II K 43 x K B 30, Stratified squamous epithelium. The connective-tissue fibres are shown in the lower part of the illustration.

Having their insertion in the cementum and extending into the marginal gingiva, certain fibres of the white connective tissue variety forming a fairly definite grouping, can be demonstrated. They comprise what is known as the marginal group (fig. 14). Passing mesio-distally from tooth to tooth, through the cemental gingivae, is found another definite grouping of fibres known as the trans-septal group (fig. 15).

PERICEMENTUM.

The pericementum is the tissue that fills the space between the root of the tooth and the wall of the alveolus. It attaches the teeth to the alveolar process. In the study of the histological structures which constitute this important tissue this order will be followed:

1. Principal fibres.
2. Fibroblasts.
3. Cementoblasts.
4. Osteoblasts.

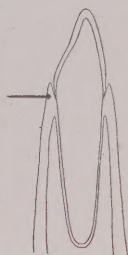
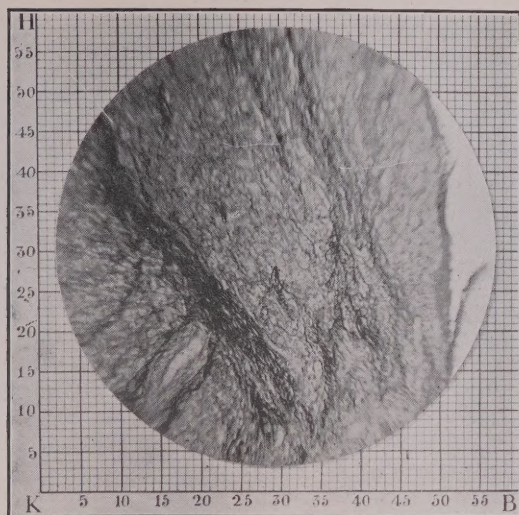


Fig. 14— x 187. Marginal group of principal fibres in the marginal gingiva.

H K 20 x K B 51, Base of gingival crevice.

H K 35 x K B 50, Crevicular epithelium.

H K 23 x K B 24 } Two bundles of principal fibres belonging to the
H K 38 x K B 39 } marginal group.

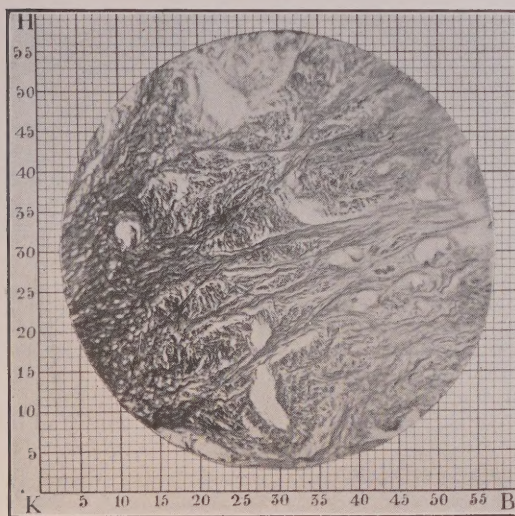


Fig. 15— x 187. Trans-septal group of principal fibres. This group passes mesiodistally from tooth to tooth through the cemental gingiva.

H K 30 x K B 18 }

H K 35 x K B 45 } Bundles of principal fibres in the cemental gingiva.

5. Osteoclasts.
6. Epithelial structures.
7. Blood-vessels.
8. Nerves.

1. *Principal Fibres.*

These fibres which compose the greater part of the pericementum are of the white connective-tissue variety and are attached to the cementum on one side and on the other extremity, depending on the location, to the connective tissues in the marginal gingiva, the fibrous mat of the alveolar mucosa, the periosteum of the alveolar process, the cementum of the approximating tooth or the bone of the alveolar process. While these fibres, as a whole, maintain a uniform progression from the crest of the process to the cemental apex, yet they exhibit a fairly definite tendency to become associated into groups. These fibre-groupings have been well described by Black. Beginning at the crest of the alveolar process and progressing apically, these groupings are as follows:

1. The alveolar crest group consisting of those fibres which pass over to, and are inserted into the crest of the alveolar process (figs. 16 and 17).

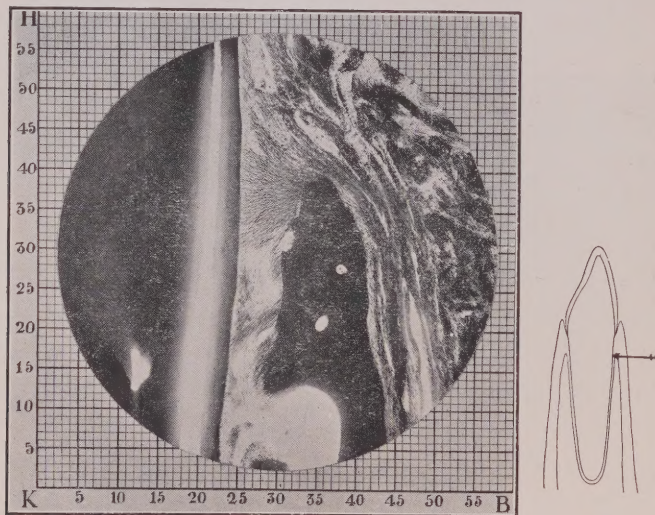


Fig. 16. Alveolar crest group of principal fibres. Note the fan-shaped arrangement of the fibres as they pass from the alveolar crest to their insertion in the cementum.

H K 38 x K B 36, Crest of alveolar process.

H K 39 x K B 29, Alveolar crest group of principal fibres.

H K 51 x K B 25 to H K 30 x K B 25, Insertion of principal fibres of this group into cementum.

H K 21 x K B 27, Pericementum.

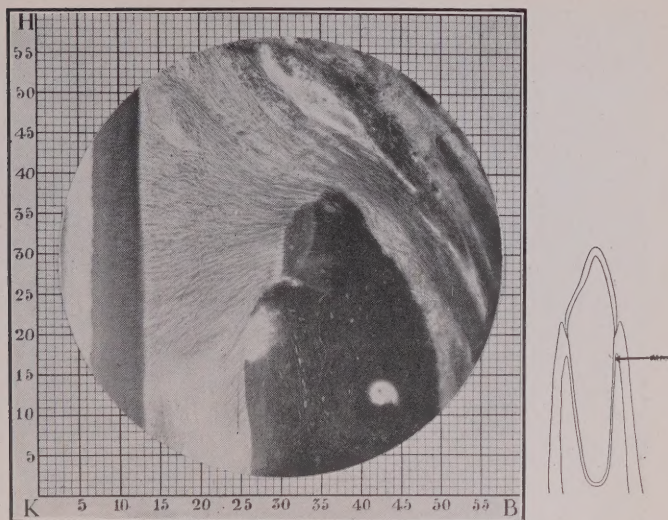


Fig. 17— x 187. Higher magnification of the alveolar crest group of principal fibres.

H K 37 x K B 37, Crest of alveolar process.

H K 37 x K B 23, Body of alveolar crest group of fibres.

H K 13 x K B 43, Haversian canal.

2. The horizontal group, consisting of those fibres which pass out at right angles to the long axis of the tooth and are attached to the alveolar process a little below its crest.

3. The oblique group, consisting of those fibres which pass from the cementum in an oblique direction occlusally, and are attached to the alveolar process. These fibres constitute the body of the pericementum and cover the main body of the root of the tooth (figs. 18 and 19).

4. The apical group, consisting of those fibres which are attached about the apex of the tooth and extend in bundles to the surrounding alveolar process (figs. 20 and 21).

2. Fibroblasts.

Found everywhere mixed among the principal fibres, there are connective-tissue cells whose cytoplasm is extended into processes, which, as a general rule, run in a direction parallel with the root. The cells are stellate or spindle-shaped and their fibres act as supporting structures to the arteries, veins and nerves.

3. Cementoblasts.

These cells are really specialized osteoblasts and lie upon the cementum of the root. Their function is to form cementum in the

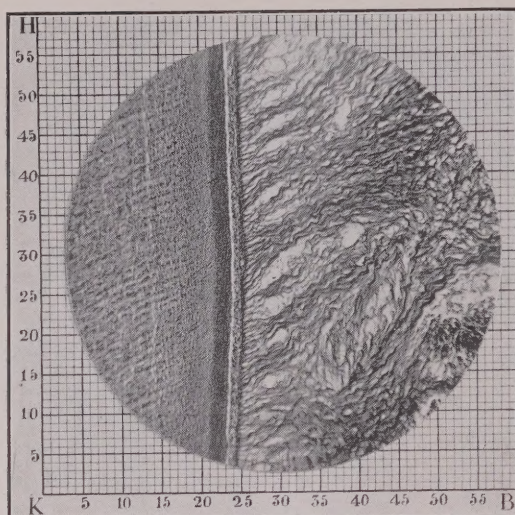


Fig. 18—x 187. Oblique group of principal fibres of the pericementum. Note that the fibres take a course nearly parallel to each other as they pass out from the tooth surface.

H K 25 x K B 25, Insertion of fibres into the cementum.

H K 23 x K B 30 } Spaces formerly occupied by epithelial cells of the pericementum.

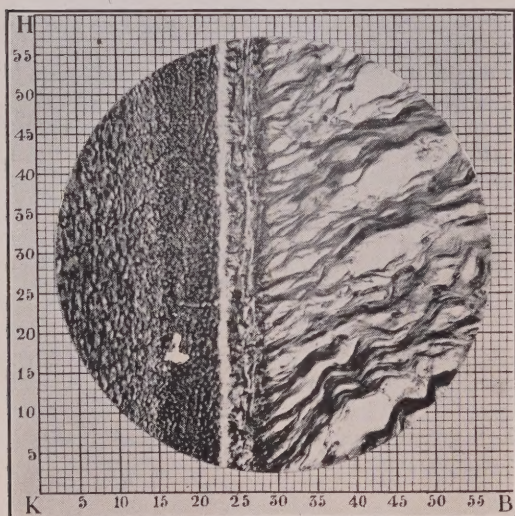


Fig. 19—x 750. Higher magnification of certain fibres belonging to the oblique group.

H K 25 x K B 23 to H K 25 x K B 28. Width of cementum.

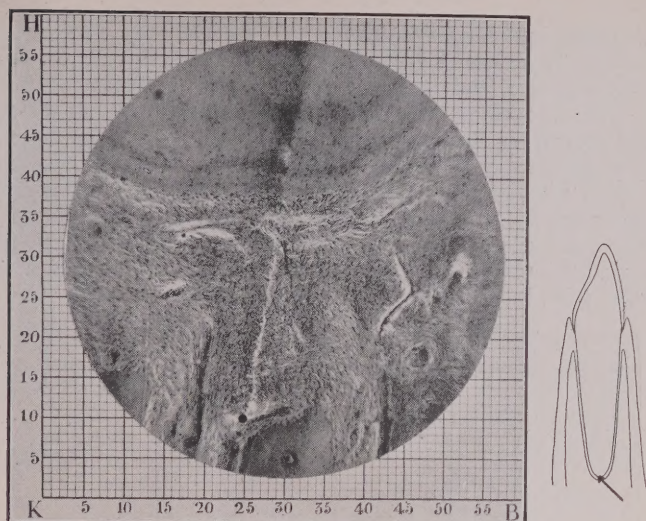


Fig. 20— x 94. Apical group of principal fibres of the pericementum. These fibres pass out from the apical cementum in all directions.

H K 38 x K B 29, Lower border of the apical cementum.

H K 23 x K B 30, Body of apical group.

H K 9 x K B 32, Alveolar bone.

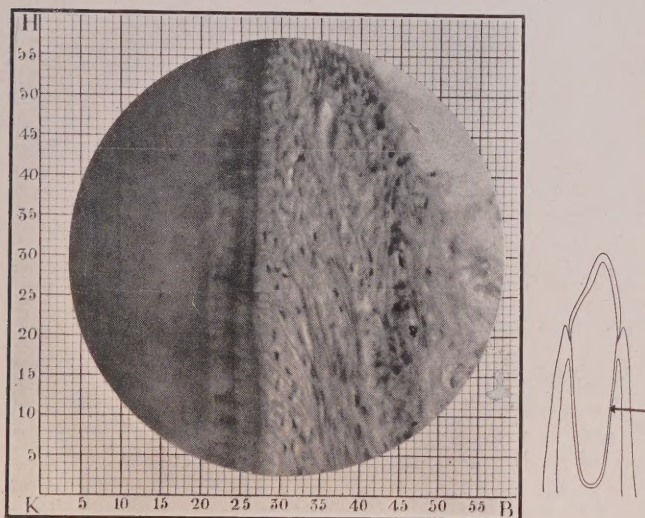


Fig. 21. Method of insertion into the cementum of the principal fibres of the gingivae and pericementum.

H K 26 x K B 27, Fibres passing into the cementum.

H K 25 x K B 20, Dentinal-cemental junction.

same manner as osteoblasts lay down the calcium salts in the building of bone. Noyes states: "They are always flattened cells, sometimes almost scale-like, and when seen from above, very irregular in outline. This irregularity in outline is due to the projections of the cytoplasm around the fibres as they spring from the cementum, the edges of the cell being notched and scalloped to fit about them. There is a central mass of granular cytoplasm which contains an oval and more or less flattened nucleus from which the cytoplasm extends in projections, passing partly around the fibres." Certain cementoblasts here and there become enclosed in the forming matrix as cement corpuscles, lying in stellate lacunae (fig. 22).

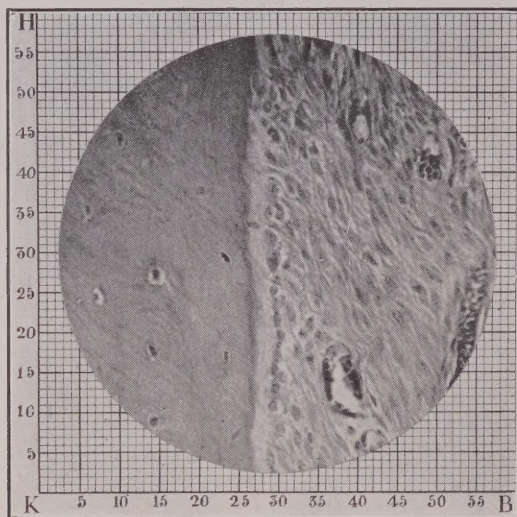


Fig. 22— x 500. Cementoblasts.

H K 30 x K B 29, Cementoblasts; these cells are shown in a vertical column on the surface of the cementum.

H K 28 x K B 15, Cement corpuscle lying in its lacuna.

H K 15 x K B 38, Blood-vessel in pericementum.

4. Osteoblasts.

The osteoblast is the embryonic or "free form" of the bone-cell and once formed, is capable of marked activity. They have the power of producing a matrix which becomes calcified. They also play a part in the absorption of bone. The osteoblasts of the pericementum do not differ from osteoblasts found elsewhere in the body. In children and adolescents they are present in large numbers in the pericementum, on the inner surface of the alveolar process, between the principal fibres. But in normal adult life they are found only

at irregular intervals. The presence of osteoblasts in great numbers on the surface of the bone is due simply to the proliferation of the osteoblasts which normally lie on the surface of the bone and in the mouths of the Haversian canals (fig. 23).

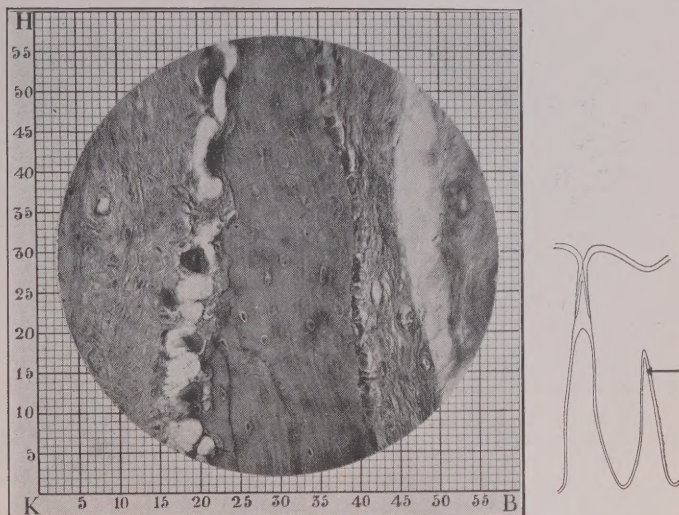


Fig. 23— x 375. Osteoblasts shown on the surface of the alveolar bone in the bifurcation of a molar.

H K 25 x K B 30, Alveolar bone.
H K 29 x K B 40, Layer of osteoblasts on surface of alveolar bone.
H K 30 x K B 20, Multinucleated osteoclast.
H K 30 x K B 10 } Pericementum.
H K 30 x K B 45 }

5. Osteoclasts.

Osteoclasts are found occasionally upon the surface of the alveolar wall and the cementum. They do not differ from the osteoclasts found elsewhere in bone. Foreign-body giant-cells are formed by the fusion of new-formed cells derived from the connective-tissue cells or from old endothelium. Arey contends that the chief source of osteoclasts, however, is from old osteoblasts and bone cells. They are large multinuclear cells which seem to be capable of absorbing bone, their cytoplasm lying in contact with the surface on which it acts (fig. 24).

6. Epithelial Structures.

Lying close to the cementum, but not in actual contact with it, are structures made up of epithelial cells in the form of strings or loops. The epithelium on the surface projects down into the connective-tissue stroma and a short distance from where they end, these cords of

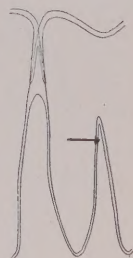
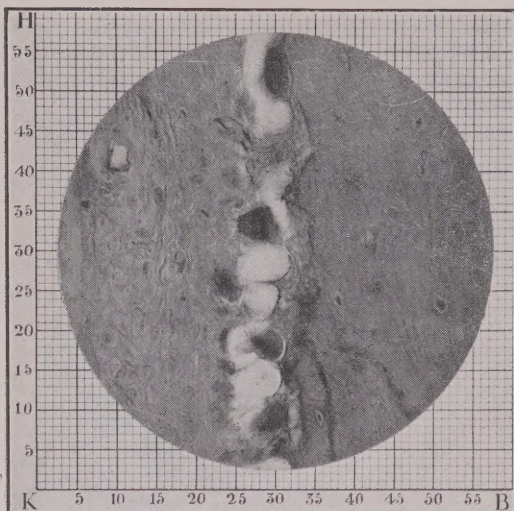


Fig. 24—x 450. Multinucleated osteoclast on the surface of the alveolar bone. Higher magnification of the osteoclast shown in preceding figure. H K 35 x K B 28, Multinucleated osteoclast. Note numerous nuclei.

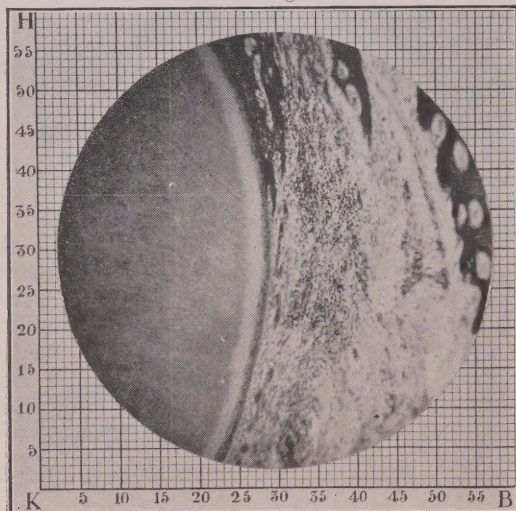


Fig. 25—x 125. Cords of epithelial cells in the pericementum. Cross section.

H K 31 x K B 30	} Epithelial cords.
H K 23 x K B 30	
H K 15 x K B 29	
H K 20 x K B 26	Surface of cementum.
H K 20 x K B 33	Pericementum.

epithelial cells appear, and in many instances pass around the entire root of the tooth (figs. 25 and 26).

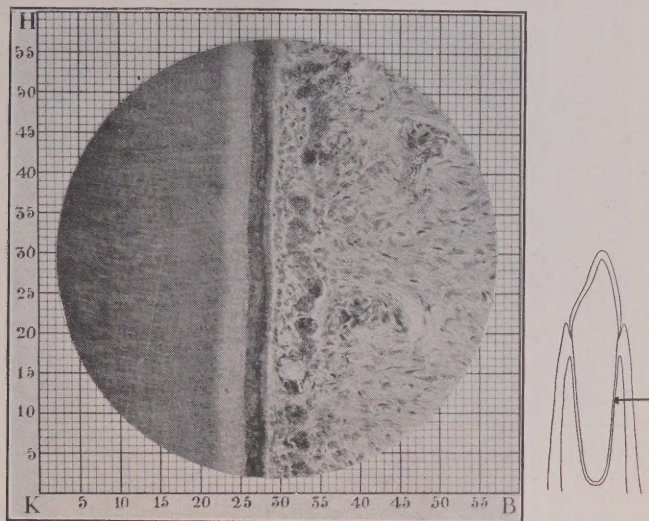


Fig. 26—x 250. Cords of epithelial cells in the pericementum. Longitudinal section.

H K 47 x K B 34 } Epithelial cords.
 H K 30 x K B 33 }
 H K 29 x K B 30, Cementoblasts.
 H K 30 x K B 27, Cementum.
 H K 16 x K B 32, Small blood-vessel in pericementum.

7. Blood-vessels.

The pericementum has an abundant blood supply. The vessels enter the periapical tissues where they branch and pass into the pericemental tissue, running parallel with the long axis of the root (fig. 27). Some of the branches pass through the apical foramen to nourish the pulp. Sometimes as many as eight or ten branches enter the body of the pericementum and passing occlusally, give off branches and anastomose with other vessels through the Haversian canals in the process. At the crest of the alveolar process, anastomosis occurs with the vessels of the gingivae, periosteum and alveolar mucosa.

8. Nerves.

The nerves of the pericementum follow the course of the blood-vessels. Ten to twenty-five medullated fibres enter the periapical tissues with the blood-vessels, some entering the pulp, others passing upward through the bone and form with the others a plexus from which filaments are given off. These terminate in free endings in the pericementum (figs. 28 and 29).

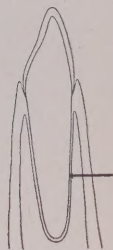
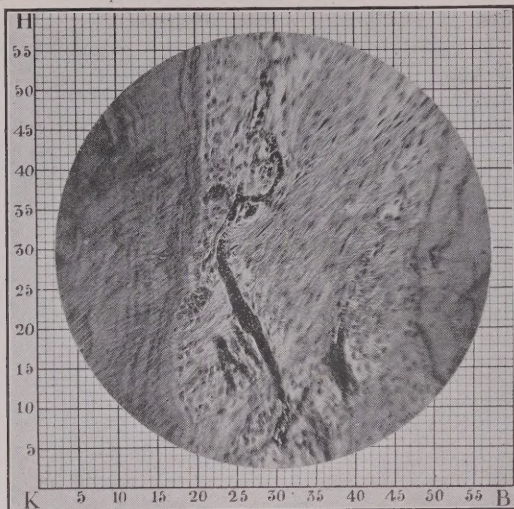


Fig. 27— x 250. Blood-vessel in pericementum. Note the unusual extent of the vessel shown on one plane.

H K 22 x K B 26, Blood-vessel at largest diameter.

H K 39 x K B 30, Branch given off from larger blood-vessel.

H K 31 x K B 21, Cementum border.

H K 31 x K B 47, Border of alveolar bone. The distance from K B 21 to K B 47 indicates the thickness of the pericementum at this point.

H K 30 x K B 35, Bundles of fibres in oblique group.

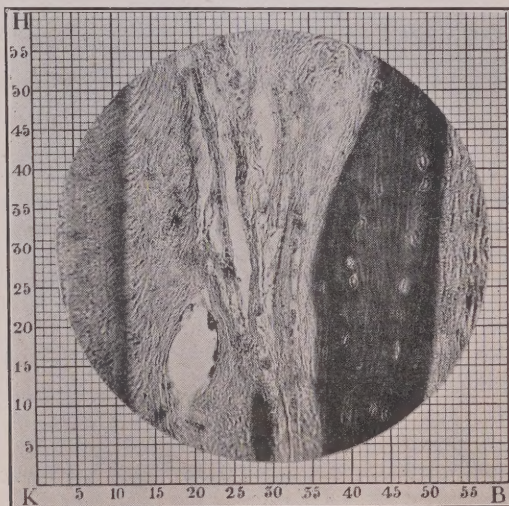


Fig. 28— x 375. Axis-cylinder of a nerve-fibre in the pericementum. II K 32 x K B 31, Small axis-cylinder of pericemental nerve, passing longitudinally.

H K 30 x K B 11, Cementum border.

H K 30 x K B 35, Border of alveolar bone.

H K 17 x K B 21, Cross section of large blood-vessel.

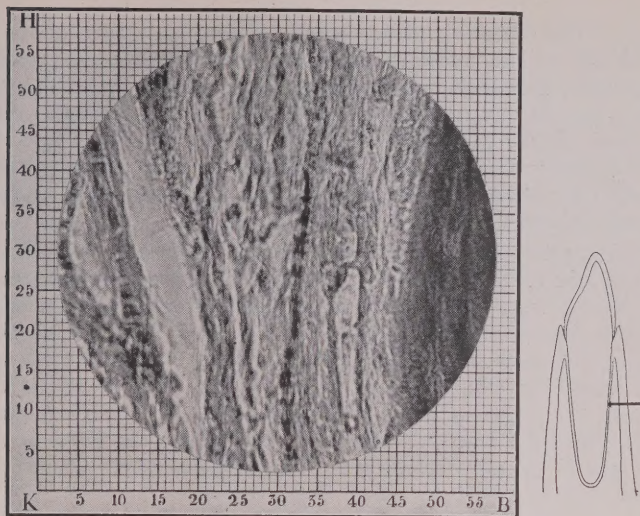


Fig. 29— x 1125. Higher magnification of the axis-cylinder of a pericemental nerve-fibre.

H K 41 x K B 33 to H K 4 x K B 32, Axis-cylinder of pericemental nerve.

THE ALVEOLAR PROCESS.

Since the bone which supports the teeth is continuous, both in its gross and minute anatomy, with the bone which makes up the body of the maxillae, it has been found difficult to define the *alveolar process*. It may perhaps be acceptably described as the bone which immediately invests the roots of the teeth together with such adjacent bone as is intimately concerned in their support.

Many efforts have been made in the past to show that the alveolar process is made up of bone having some peculiar characteristics which differentiate it from other osseous tissue in the body. We have been unable to find any histologic evidence to warrant this assumption. It has a specialized function, and because of its function and its location, it is peculiarly subject to disease. This fact does not, however, justify the assumption that loss of the alveolar process is an inevitable phenomenon.

Bones are formed either by ossification of connective-tissue membranes or by the replacement of cartilage by osseous tissue. They nearly always develop from a connective-tissue foundation, even where they are laid down in places formerly occupied by cartilage. Membranous bones seem to be produced by a change in the function of certain cells which acquire the property of laying down an intercellular, formless ground-substance in which they bury them-

selves. This later becomes calcified. These cells are known as osteoblasts. The osteoblasts form for themselves, in the hyaline ground-substance they have produced, little cavities in which they lie, their numerous tiny branches extending out in every direction, into small canaliculi. The osteoblasts thus become stationary and are termed "bone-cells." At this stage, the tissue is known as osteoid tissue. In a short time, there takes place, a deposition of calcium throughout, and the tissues become hard bone.

Investigators are not unanimous in their views as to the manner in which the calcium salts are laid down. The process consists of a deposition, in the organic ground-substance, of very fine granules, which fuse together to form a homogeneous mass. Watt, of the University of Toronto, has observed these granules only at the extreme advancing edge of new bone. These granules might represent the product of a process of either precipitation or secretion. Three main conceptions have been put forward to explain the deposition of the lime salts in bone. According to Watt, these may be summed up as follows:—

1. The salts are deposited by precipitation in the matrix of a soluble salt of calcium, such as the chloride, by carbonates and phosphates found in the tissues.

2. A modified precipitation theory. According to this theory a soluble double-salt, calcium carbonophosphate, is carried in the blood and deposited in the bone by change of carbon dioxide concentration in this tissue. This precipitates the double salt, which then breaks up into calcium carbonate and di-calcium phosphate, which latter is immediately converted into the tri-calcium phosphate.

3. The secretion theory. This explains the presence of these salts as due to cellular activities, calcium being taken from the blood, and combined with the carbonate radical in the cell, or with the phosphate radical, this latter being derived from the nucleus, either as a normal cell product or as a product of degeneration.

In a recent work on the deposition of bone salts, Watt has expressed his views as follows:—"The most logical complete explanation of the deposition of bone-salts, it seems to me, is to be obtained by combining two of the above views. Evidence is in favor of the calcium being carried in the blood as the soluble double salt, calcium carbonophosphate, which supplies to the bone, both carbonate and phosphate in exactly the proper proportion. This salt is taken from the blood, and deposited in the bone by the action of the osteoblasts. This view also provides for a reversibility of direction of travel of the calcium. The cell may take up the bone-salts and pass them back into the blood, a process which is well known and recognized in bone absorption."

Macewen holds the view that the bone-cell has the function of surrounding itself with a calcareous zone at the period when the osteoblast reaches maturity and becomes stationary in its ground-substance.

There is abundant evidence that the osteoblasts have the power of absorbing bone. Nothing could be more convincing in this relation, than the investigations of Gallie and Robertson of Toronto, in the repair of bone. They have shown, in their numerous experiments with grafts of bone, which are absorbed and replaced by new osseous tissue, that this process of absorption is almost solely dependent upon the activity of the osteoblasts.

PART II: GINGIVITIS.

Gingivitis may be defined as the re-active phenomena of the gingival tissues to any injury done to them.

Anything that is capable of injuring the gingival tissues may produce in them the phenomena of inflammation. The essential thing about the harmful agent always is, that it injures the tissues, as inflammation takes place because tissue has been injured. The reaction of the tissues to any injurious agent and to the injury produced by it, differs according to the nature of that agent and to the severity of the injury. The function of that reaction is to eliminate the noxious agent, to counteract its action and to repair the injury produced.

Mallory states:—"The reaction may be evidenced chemically by metabolic changes, such as alteration of secretion and excretion: morphologically, by the presence of serum, fibrin, and leukocytes and by the proliferation of cells; and physiologically, by alteration of functional activity." Again he states:—"The morphologic changes which take place as the result of the action of various injurious agents vary greatly, depending on the strength and character of the latter." Also: "In general we may divide the injurious agents into two groups, the strong and the mild irritants (with all gradations between) although it is difficult to confine some of them exclusively to either group."

Due to the epoch-making discoveries of Virchow, Cohnheim, Marchand, and others, our conception of the changes which take place in the tissues as the resultant of the action of strong injurious agents, has been clarified, and it is generally acknowledged that acute inflammation is anatomically manifested both macroscopically and microscopically by three main processes. Mallory has described them as follows:—

- "1. Circulatory disturbances.
2. Inflammatory exudation.
 - (a) Exudation of lymph (including formation of fibrin).
 - (b) Emigration of leukocytes (chiefly of the polymorphonuclear leukocytes).

3. Proliferation of emigrated endothelial leukocytes and lymphocytes, of fibroblasts, of vascular endothelium and of epithelial cells, if included in the lesion."

A detailed description of the phenomena of acute inflammation, is a more or less laborious process and one which shall not be attempted in this paper. As these changes induce certain gross anatomical appearances, which, as a rule, can be distinguished clinically, and are known as the classic signs of acute inflammation, namely, redness, heat, swelling and pain, it is advised that students of periodontal pathology should study these phenomena through the medium of a standard text-book of general pathology.

The reaction of the tissues to *mild* injurious agents from a histopathological point of view is of equal importance to the reaction to *strong* irritants, manifested in acute inflammation. Its significance in dental pathology has not been fully appreciated. The *mild* injurious agents include micro-organisms which produce weak toxins, and also strong toxins from different sources which have been so diluted as to act as mild irritants. From the standpoint of focal infection, the greatest problem in the dental profession to-day, and from our present viewpoint as well, the inflammatory reaction to these mild irritants is of much greater moment than the reaction to *strong* injurious agents.

The lack of appreciation, pathologically, of the relation of these reactions to those produced by the strong irritants, and the fact that when an injurious agent acts mildly, one or all of the classic signs of acute inflammation may be lacking, account largely for the obscurity surrounding this phase of the subject.

According to Mallory, "The most common inflammatory reaction to mild irritants consists of an exudation and proliferation of endothelial leukocytes which sometimes accumulate in very large numbers. To the endothelial leukocytes may be added serum (from which fibrin may form) lymphocytes, polymorphonuclear leukocytes and rarely eosinophiles."

Again,—“Other injurious agents attract lymphocytes in large numbers so that focal accumulations of some size may occur in various organs and tissues: for instance in the heart, kidney, adrenal and skin.”

The gingivae are frequently the site of inflammatory processes, which *often* persist over a considerable period of time. These manifestations of the defensive processes of the gingival tissues are revealed only to the competent observer, his ability to interpret them depending upon his understanding of the fundamental principles of inflammation, and of the histology of the tissues involved. The phenomena of *acute* inflammation are *displayed* in the gingival tissues as variegated clinical pictures; but the *inflammatory* reactions to mild injurious agents are *generally unapparent* and are detected with difficulty.

It must be kept in mind that bacterial invasion of the gingivae rarely takes place without a pre-existing state of local lowered resistance. Careful investigations have proved that from a bacteriological standpoint, the causative factors of these infections are common to all mouths. All factors in the disturbance of capillary circulation can be regarded as productive of lowered resistance. Accumulations of foreign material, restorative impingement, food impaction, incorrect mouth toilet, etc., in this relation are so well known as to need no further comment.

During a period in which the alveolar crest may be under great strain in its effort to maintain a balance of the forces acting against it, as in traumatic occlusion, and for the period immediately following disturbance of that balance, the marginal gingivae in many instances presents clinically a characteristic hyperemia. This is to be regarded as a sign of pericemental trauma. Upon establishment of equilibrium of the forces, by readjustment of mechanical factors that to a considerable degree are under the control of the operator, namely, the point of application and the direction of the initial force, these tissues as a rule, quickly regain their normal tone and color. When the tooth is pushed against the alveolar crest and associated alveolar wall, an abnormal condensation of pericemental tissue lying between the tooth and these areas takes place. Dependent upon the intensity of this condensation, the blood-vessels are more or less constricted and the flow of blood through them is partly cut off. When the pressure is removed there is a consequent dilatation of the blood-vessels. This condition is reflected in the terminal capillary loops in the marginal gingivae, a clinically observable disturbance.

Inflammations of the gingivae may be classified as follows:—

1. Marginal gingiva.
 - A. Acute { Non-Ulcerative.
Ulcerative (fuso-spirillary).
 - B. Sub-acute.
 - C. Chronic { Non-Ulcerative.
Hyperplastic
Ulcerative (fuso-spirillary).
(Crevicular).
(Calcular).
2. Cemental Gingiva.
 - A. Acute { Non-Ulcerative.
Ulcerative (fuso-spirillary).
 - B. Sub-acute.
 - C. Chronic { Non-Ulcerative.
Ulcerative.

It is not our intention to give here a detailed description of these thirteen types of gingivitis. Nevertheless a brief description of some of the more salient ones is a prerequisite in the understanding of some of the more complicated periodontal conditions to be described later.

1. *Marginal gingiva.*

ACUTE FUSO-SPIRILLARY GINGIVITIS.

Regarding this form of gingival disease, Stillman and McCall have stated:—"The chief characteristics are:—sudden onset; a sensitive and serpiginous ulcer, consisting of necrotic tissue elements and a creamy pasty exudate; characteristic fetor of the breath; hemorrhages, either spontaneous or induced by touch; a neurosis exhibiting malaise, mental depression, insomnia, restlessness; loss of appetite; profuse flow of saliva, often with a metallic taste; temperature above normal."

The following photomicrographs were made from sections taken from the gingivae in a case of this disease which occurred about the upper left central, lateral, and cuspid. Upon microscopic examination, it is observed that most of the epithelial cells have been cast off, and many of those present are swollen and filled with drops of exudate which crowd the nuclei against the cell-body. The exudation consists of serum and leukocytes; fibrin has been deposited as a layer of interlaced fibrils and mesh works matted together entangling leuko-

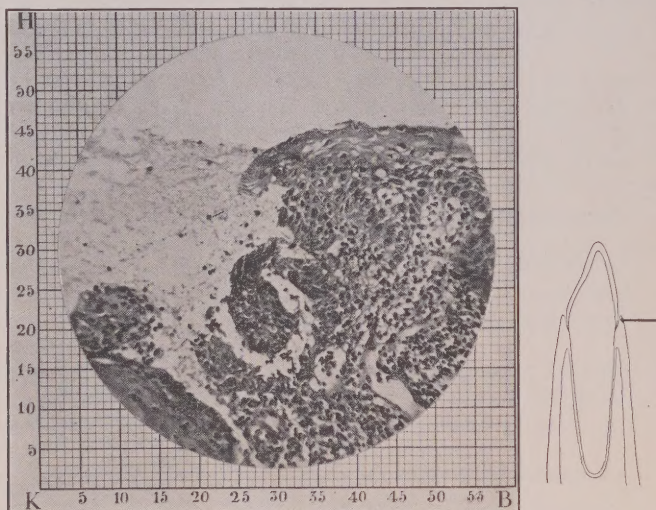


Fig. 30— x 280. Acute Fusio-Spirillary Gingivitis. Specimen taken from the marginal gingiva. Much epithelium has been lost and replaced in part by a fibrinous exudate.

The area shown as being bounded approximately by the lines within the points, H K 45 to H K 25, and K B 28 to K B 25, has lost its epithelium and some underlying connective tissue, and now shows a faintly stained fibrinous exudate.

H K 43 x K B 37, Epithelium as yet intact.

H K 35 x K B 52, Connective-tissue papilla, showing leukocytic infiltration.

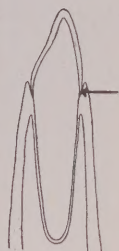
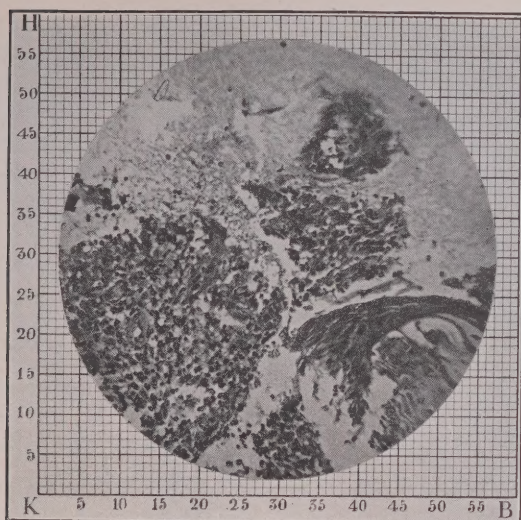


Fig. 31— x 280. Acute Fusio-Spirillary Gingivitis. Specimen removed from the marginal gingiva. The fibrinous exudate which has replaced part of the lost gingival tissue is shown in the upper part of the photomicrograph. The remaining tissue exhibits pronounced leukocytic infiltration.

cytes and bacteria. Red blood-cells have escaped from the blood-vessels and are found free in the surrounding mesh-work (figs. 30 and 31).

CHRONIC NON-ULCERATIVE.

From a microscopic examination of marginal gingivae showing long standing inflammatory reaction, the following has been noted. There is a large infiltration of leukocytes in the connective-tissue stroma beneath the surface epithelium of the marginal gingivae. These cells lie between the bundles of fibres and in some instances are present in the papillae. The blood-vessels are dilated and filled with red blood-cells. A very marked feature is the predominance of plasma cells. Lymphocytes and eosinophiles are also present. The main function of the lymphocytes appears to be the neutralization or disposition of injurious substances which are being absorbed through the lymphatics. It is not known just what function the eosinophile has, but it is thought to be the counteraction of certain injurious chemical substances (fig. 32).

HYPERPLASTIC.

The mucous membrane appears to be unchanged as a general rule, although in some areas the epithelium seems to project into the

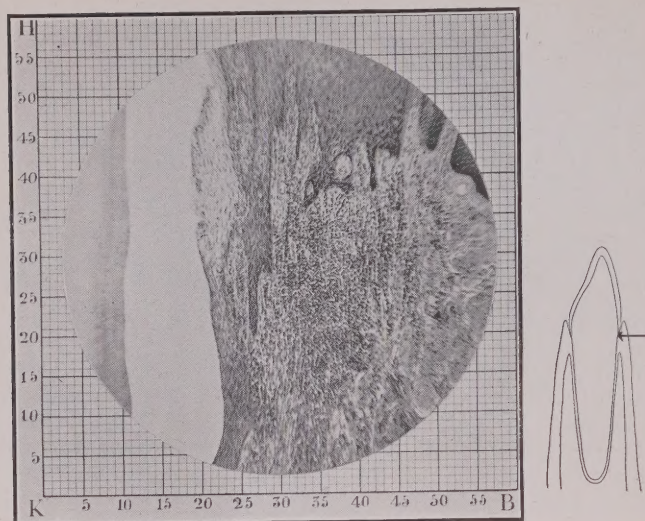


Fig. 32—x 125. Chronic Non-Ulcerative Gingivitis. This is the type of chronic gingivitis most commonly observed in the marginal gingiva.

H K 25 x K B 18, Gingival crevice.

H K 20 x K B 24, Crevicular epithelium.

H K 28 x K B 35, Pronounced infiltration by lymphocytes and plasma cells.

H K 50 x K B 40, Epithelium on external surface of marginal gingiva.

underlying tissue somewhat farther than normally. The bulk of the mass is made up of fibrous connective tissue, the bundles of which form trabeculae ramifying in all directions. Many of the blood-vessels are dilated. In the tissue-spaces around the blood-vessels and between the bundles of connective tissue, the cellular elements are very greatly multiplied. In the following slides, the majority of the cells are plasma cells, many of which contain droplets of hyalin (figs. 33 and 34).

CHRONIC ULCERATIVE (Crevicular).

The gingival crevice is normally cleansed by a serum which is derived from the marginal and cemental gingivae. When through growth of micro-organisms on the cervical enamel surface, the crevice becomes foul, especially when facilitated by a holding medium (such as etched enamel, that is, removal of the superficial cementing substance from between the enamel rods), necrosis of the crevicular epithelium takes place. By the death of epithelial cells, there is provided a suitable medium for the growth of micro-organisms and their penetration is facilitated. The resultant pathological condition is ulceration.

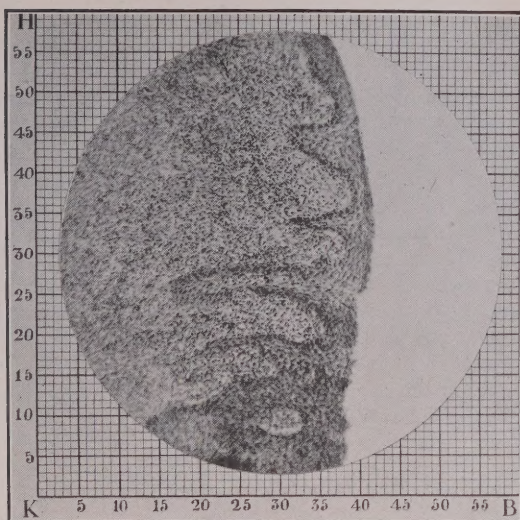


Fig. 33— x 94. Hyperplastic Gingivitis.

At H K 25 x K B 17 and H K 9 x K B 13, the epithelium appears to project into the underlying connective tissue farther than normal.

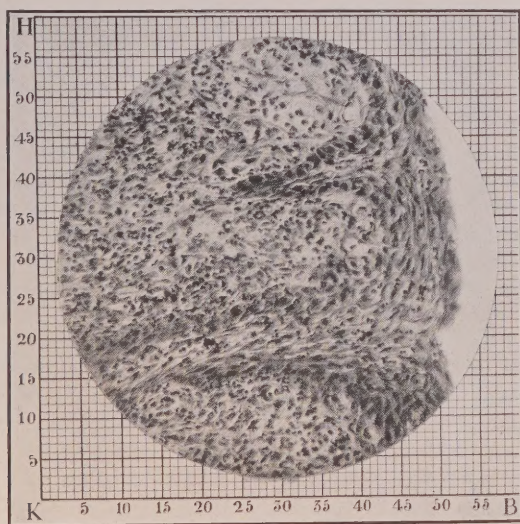


Fig. 34. Higher magnification of specimen shown in preceding illustration.

H K 17 x K B 9, Extremity of epithelial ingrowth.

Entire connective-tissue area shows an increase in its cellular elements and a marked leukocytic infiltration.

2. *Cemental Gingiva*

SUB-ACUTE.

This type of reaction in the cemental gingiva, in no way differs from that occurring in the marginal gingiva. The majority of these lesions are found at the base of the gingival crevice, where through imperfect junction of the epithelial cells with the cementum, or because of the extreme thinness of this defensive covering, the tissue underlying this area is not adequately protected. Plasma cells and lymphocytes are the predominating leukocytes.

We wish to more clearly distinguish these definite inflammatory reactions evidenced by such infiltration, from the normal condition existing in the gingival tissues in which slight collections of similar cells are constantly present.

A typical feature of the microscopic picture is the proliferation of the crevicular epithelium downward along the cementum. One of two things, as a rule, takes place. In the first place, by progression of the inflammatory process, ulceration is established and the proliferating epithelium is included in the loss of tissue. In the second instance, the epithelium, by proliferation, extends for some distance along the cemental surface. Then, separation from the cementum takes place with the resultant denudation of the cementum and the formation of a pocket. Infection of the tissue at the base of this pocket generally occurs, sooner or later, frequently with the establishment of ulceration (figs. 35 and 36).

CHRONIC NON-ULCERATIVE.

This type of inflammation in the cemental gingivae resembles that occurring in the marginal gingivae and described previously. The leukocytic infiltration, chiefly plasma cells and lymphocytes, is present between the bundles of fibres and occasionally in the papillae. In this type of lesion, there is to be found a tissue architecture which differentiates it from the sub-acute type, consisting in the presence not only of lymphocytes and plasma cells, but also of connective-tissue cells in various stages of development, from the fibroblast to the mature connective-tissue cell.

A suppurative gingivitis frequently follows this type, due to acute inflammatory changes in which the exudate passes through the epithelial covering to the pocket. A characteristic of this suppurative but non-ulcerative condition is the fact that the epithelium covering the denuded soft tissues remains intact. The epithelial cells are not lost until actual ulceration takes place.

Because of the mild character of the symptoms, this condition is readily overlooked in clinical examination. Because it is one of the early phases of a still more serious condition, we would stress the importance of its early detection and treatment (fig. 37).

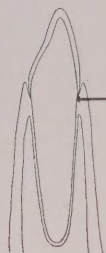
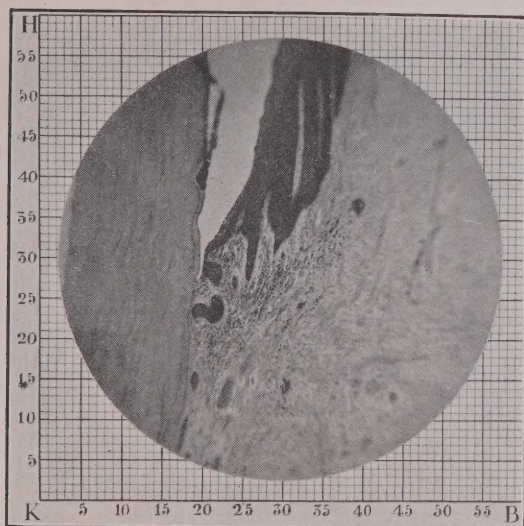


Fig. 35— x 94. Sub-acute Cemental Gingivitis. In the area adjacent to the base of the gingival crevice, there is to be seen a definite leukocytic infiltration (chiefly plasma cells and lymphocytes).

H K 29 x K B 20, Base of gingival crevice. Note imperfect junction of epithelium with cementum.

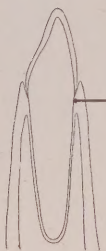


Fig. 36— x 375. Higher magnification of the specimen shown in the preceding illustration. The base of the gingival crevice.

H K 29 x K B 25, Base of gingival crevice; imperfect junction of epithelium with cementum.

H K 37 x K B 35

HK 22 x K B 27

Areas of marked leukocytic infiltration.

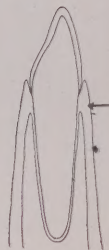
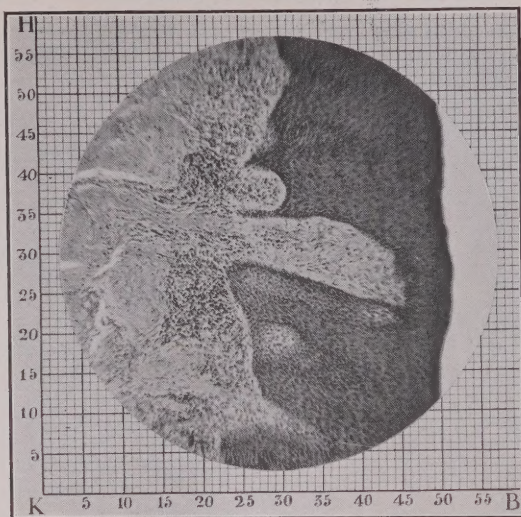


Fig. 37— x 125. Chronic Non-Ulcerative Cemental Gingivitis. This photomicrograph shows the external surface of the cemental gingiva. This is a parallel type to the chronic non-ulcerative marginal gingivitis. See Fig. 32.

H K 40 x K B 22 Areas of leukocytic infiltration, largely plasma cells
 H K 25 x K B 20 and lymphocytes.
 H K 30 x K B 40, Connective-tissue papilla.

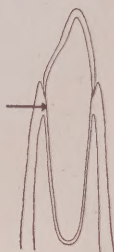
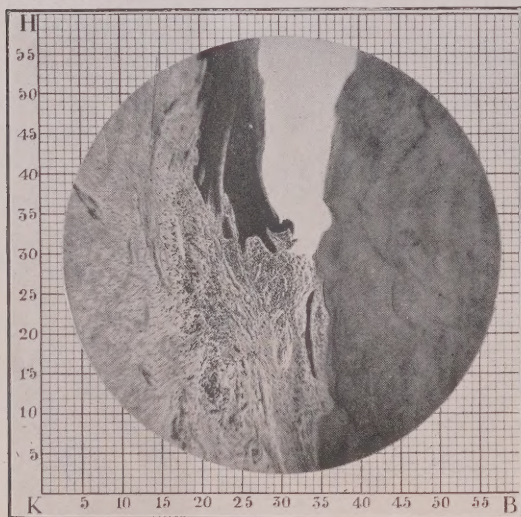


Fig. 38— x 94. Chronic Ulcerative Cemental Gingivitis. This specimen shows ulceration in the connective tissue at the base of the gingival crevice. Note the extensive infiltration in the adjacent tissue.

H K 30 x K B 33, Ulceration at the base of the gingival crevice. Marked leukocytic infiltration extending as far as H K 12 x K B 21.

H K 22 x K B 34, Extension of proliferating epithelium in process of being included in the superficial loss of tissue.

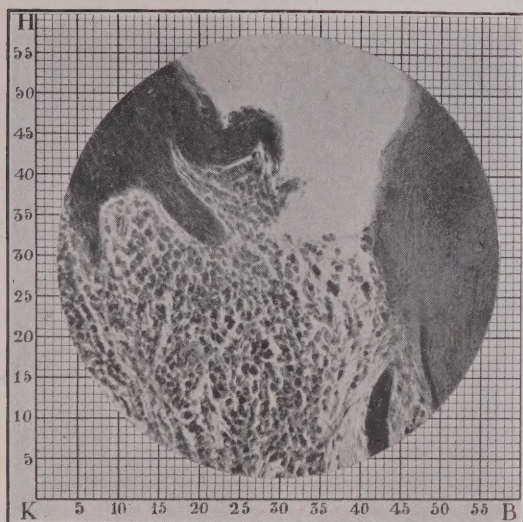


Fig. 39—x 375. Higher magnification of the specimen shown in the preceding illustration, showing ulceration of the connective tissue at the base of the gingival crevice.

H K 32 x K B 35, Ulceration at the base of the gingival crevice.
 H K 14 x K B 43, Proliferating epithelial extension.
 H K 50 x K B 20, Crevicular epithelium.

CHRONIC ULCERATIVE.

Due to increased virulence of the bacteria, or lowered resistance by the action of factors which may cause a disturbance of the capillary circulation, exacerbations of acute inflammation may occur. These frequently lead to an ulceration at the base of the gingival crevice and which may persist for long periods of time. They thus become chronic in character although having had their inception in an acute inflammatory process. However there is a tendency at all times, due to the natural resistance of the organism, for this process to merge into a chronic non-ulcerative condition (figs. 38 and 39).

PART III: RAREFYING PERICEMENTITIS FIBROSA.

This is a chronic and progressive lesion of the pericementum which results in the rarefaction and destruction of alveolar bone. The process consists of the formation, in the pericementum, of a new tissue which, on the one hand, changes the normal arrangement of the pericemental structures, and, on the other, replaces the bone substance of the alveolar process. These changes in the pericementum and the alveolar bone are concomitant lesions. This new tissue subsequently assumes the form of a fibrillar connective tissue (Figs. 40, 41, 42, 43, 44).

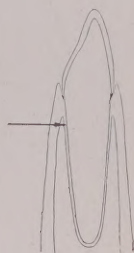


Fig. 40—x 94. Rarefying Pericementitis Fibrosa. Low magnification of tooth, pericementum and alveolar process, showing the formation of fairly large nodular masses of new tissue in the pericementum with resultant concavities in the inner alveolar wall.

H K 35 x K B 25, Alveolar process. H K 35 x K B 35, Pericementum. H K 35 x K B 40, Cementum. H K 35 x K B 45, Dentine. H K 49 x K B 33, H K 39 x K B 33, H K 30 x K B 30, H K 28 x K B 30, H K 13 x K B 32, H K 5 x K B 35; Six nodular masses of new tissue in the pericementum.

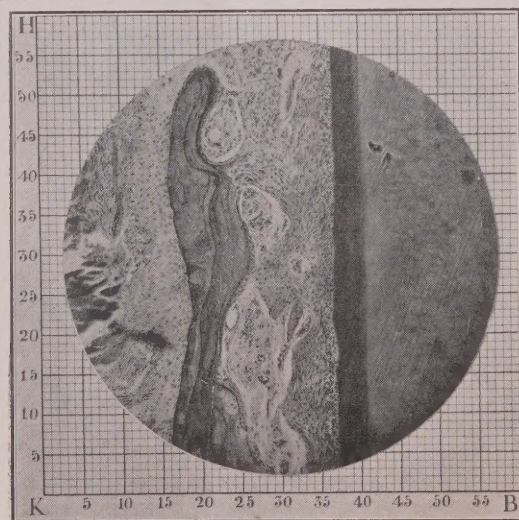


Fig. 41—x 94. Rarefying Pericementitis Fibrosa. Low magnification of tooth, pericementum and alveolar process showing nodular and irregular masses of new tissue in the pericementum.

H K 53 x K B 20, Crest of alveolar process. H K 45 x K B 30, Pericementum. H K 45 x K B 23, Nodular masses of new tissue in the pericementum. H K 35 x K B 27, Large irregular mass of new tissue. H K 15 x K B 25, Dentinal-cemental junction. H K 55 x K B 40, Dentinal-cemental junction.

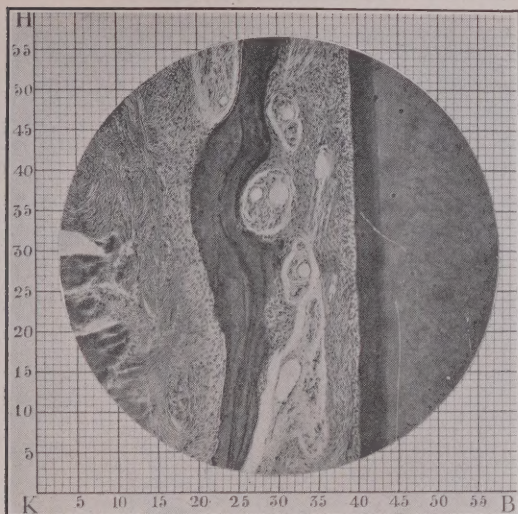


Fig 42— x 94. Rarefying Pericementitis Fibrosa. Low magnification of alveolar process, pericementum and tooth showing nodular and irregular masses of new tissue in the pericementum.

H K 40 x K B 24, Alveolar process. H K 50 x K B 37, Pericementum. H K 55 x K B 39, Border of cementum.

H K 45 x K B 31 } Nodular masses of new tissue.

H K 35 x K B 28 }

H K 13 x K B 34, Large irregular mass of new tissue.

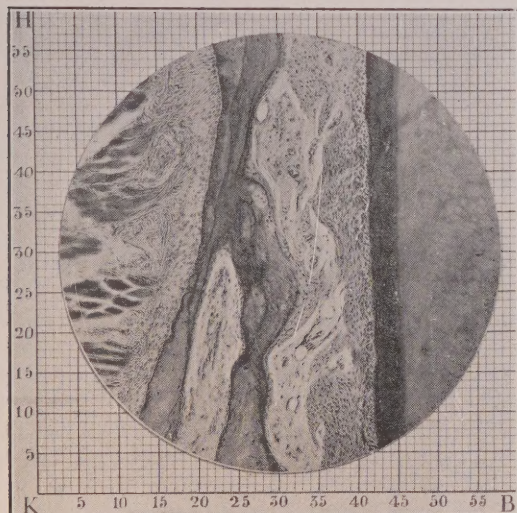


Fig. 43— x 94. Rarefying Pericementitis Fibrosa. Low magnification of alveolar process, pericementum and tooth showing two large irregular masses of new tissue in the pericementum, and one in the alveolar bone.

H K 52 x K B 25, Alveolar process. H K 53 x K B 35, Pericementum.

H K 55 x K B 41, Cemental border.

H K 43 x K B 30 }

H K 15 x K B 32 } Large irregular masses of new tissue in pericementum.

H K 20 x K B 23, Large mass of new tissue in alveolar process.

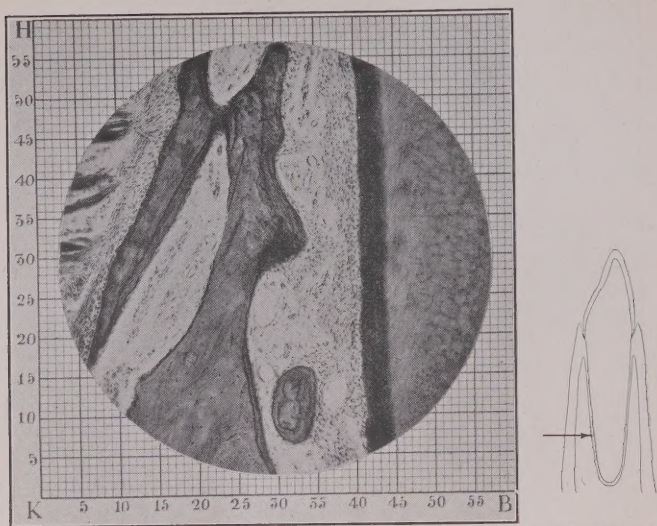


Fig. 44— x 94. Rarefying Pericementitis Fibrosa. Low magnification of alveolar process, pericementum and tooth showing masses of new tissue.

H K 33 x K B 27, Alveolar process.

H K 30 x K B 33, Pericementum.

H K 25 x K B 42, Cementum.

H K 40 x K B 33 } Masses of new tissue in pericementum.

H K 20 x K B 32 }

H K 25 x K B 17, Mass of new tissue in alveolar process.

H K 10 x K B 32, Segment of alveolar bone.

In this new tissue, the reaction around the blood-vessels is a conspicuous feature. There is a proliferative change of the endothelial cells lining the blood-vessels, leading, in many instances, to partial or complete occlusion of the vessel lumen. Endothelial cells are to be seen, also, in the new tissue surrounding the blood-vessels, accompanied by occasional lymphocytes and plasma cells. A few fibroblasts are present. In other words, there is manifested a chronic and progressive tissue response wherein new fibroblasts make their appearance during the progress of a very low grade of chronic inflammation (Figs. 45, 46, 47, 48, 49).

In the production of this reaction, however, there is no significant development of new capillaries, and the tissue cannot be looked upon as typical granulation tissue. Nevertheless, there has taken place a new-growth of tissue, its various elements constituting at times a diffuse new structure, and, at other times, nodular and irregular masses of new tissue growth (Figs. 50, 51, 52, 53, 54, 55, 56, 57, 58, 59).

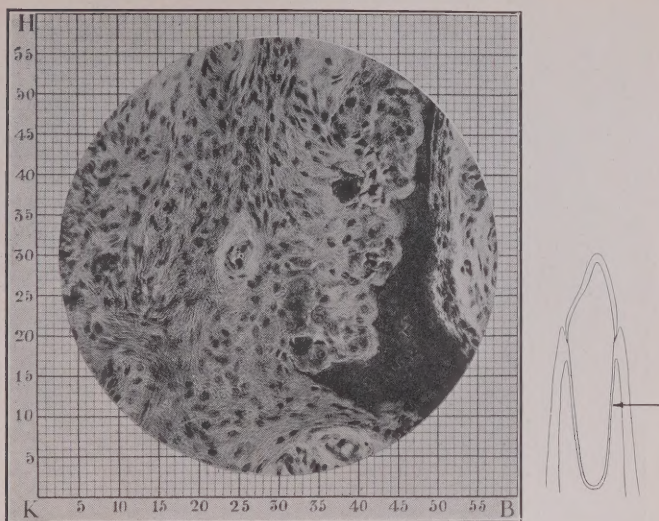


Fig. 45—x 375. Rarefying Pericementitis Fibrosa. Small nodule of new tissue in the body of the pericementum.

H K 30 x K B 25, Small nodular mass of new tissue.

H K 15 x K B 45, Small segment of alveolar bone undergoing absorption.

H K 22 x K B 35 Osteoclast.

H K 30 x K B 25, Blood-vessel in small mass of new tissue.

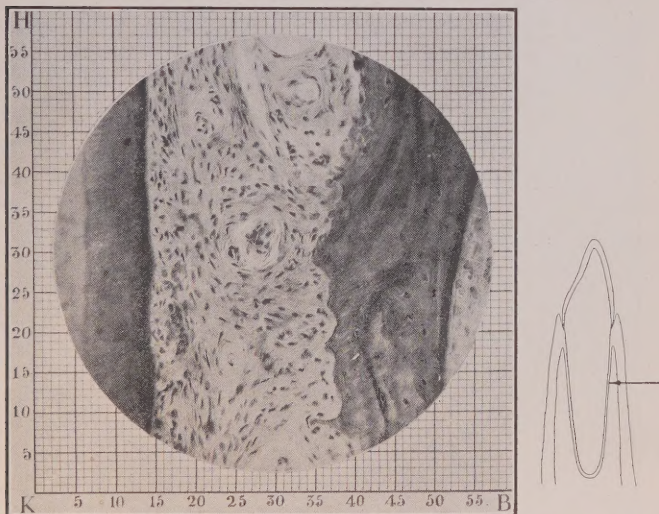


Fig. 46—x 375. Rarefying Pericementitis Fibrosa. Small nodule of new tissue in the body of the pericementum.

H K 31 x K B 27, Small nodule of new tissue in the pericementum.

H K 43 x K B 6, Dentinal-cemental junction.

H K 53 x K B 14, Border of the cementum.

H K 25 x K B 37, Inner surface of alveolar bone. Note its eroded appearance.

H K 32 x K B 27, Blood-vessel in small nodule.

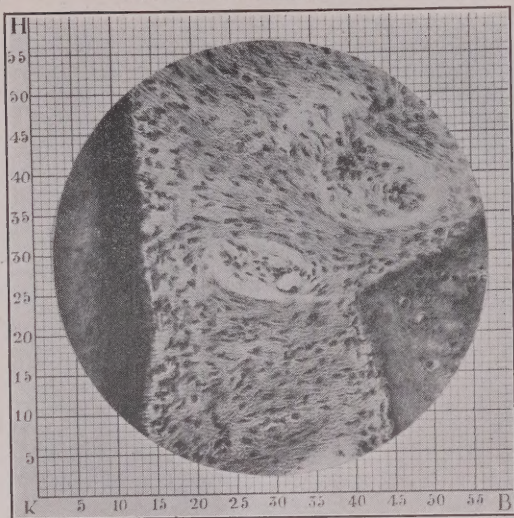


Fig. 47— x 375. Rarefying Pericementitis Fibrosa. Small nodule of new tissue in the pericementum.

- H K 28 x K B 27, Small nodule of new tissue.
 H K 27 x K B 31, Blood-vessel in nodule.
 H K 37 x K B 42, Large mass of new tissue.
 H K 20 x K B 14, Cemental border.
 H K 20 x K B 41, Alveolar wall.
 H K 15 x K B 30, Principal fibres of the pericementum.

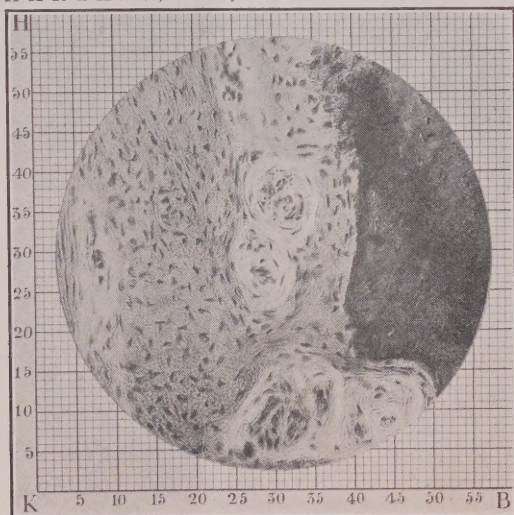


Fig. 48— x 375. Rarefying Pericementitis Fibrosa. Two small nodules of new tissue in the pericementum.

- H K 36 x K B 31, Upper nodule of new tissue.
 H K 27 x K B 28, Lower nodule of new tissue.
 H K 32 x K B 28, Blood-vessel in lower nodule.
 H K 23 x K B 38, Alveolar wall.

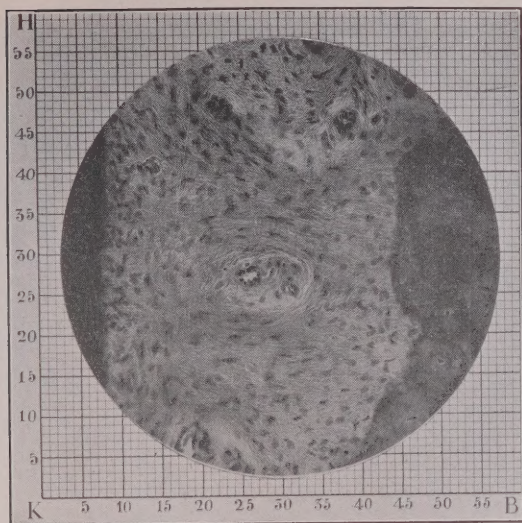


Fig. 49—x 375. Rarefying Pericementitis Fibrosa. Small mass of new tissue in the body of the pericementum.

H K 27 x K B 30, Small nodule of new tissue. H K 27 x K B 25, Blood-vessel in nodular mass. H K 32 x K B 28, H K 20 x K B 25, Principal fibres of the pericementum. H K 45 x K B 8, Cemental border. H K 25 x K B 43, Alveolar wall.

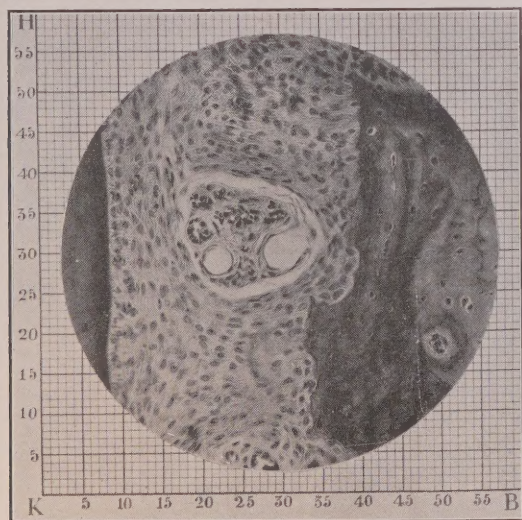


Fig. 50—x 375. Rarefying Pericementitis Fibrosa. Large mass of new tissue encroaching upon the surface of the alveolar process with resultant absorption of bone. Note the tiny bay-like excavation opposite the mass of new tissue.

H K 33 x K B 25, Large nodular mass of new tissue. H K 36 x K B 20, H K 32 x K B 20, Blood-vessels in new tissue. H K 25 x K B 38, Excavation of the alveolar wall. Note the row of osteoblasts on the border of the excavation. H K 45 x K B 8, Cemental border. H K 40 x K B 31, Principal fibres of pericementum. H K 15 x K B 34, Surface of alveolar bone.

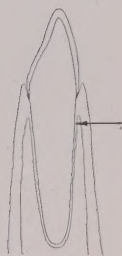
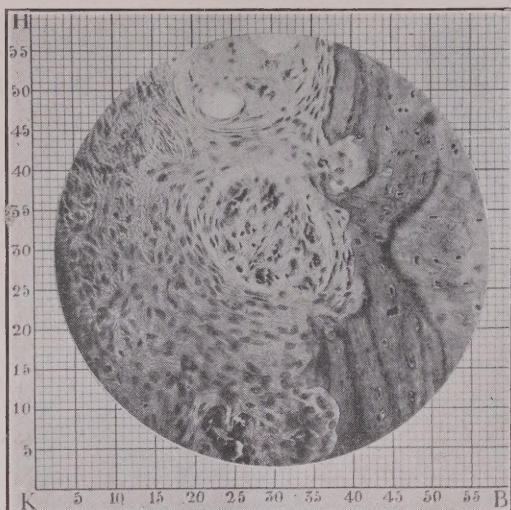


Fig. 51— x 375. Rarefying Pericementitis Fibrosa. Large mass of new tissue encroaching upon the surface of the alveolar process with resultant beginning of bone absorption. Note small inlet and large excavation in the alveolar wall.

H K 30 x K B 28, Large nodule of new tissue. H K 26 x K B 28, Blood-vessel in new tissue. H K 40 x K B 41, Small inlet in alveolar wall. H K 24 x K B 29, Large excavation. H K 20 x K B 28, Principal fibres of pericementum.

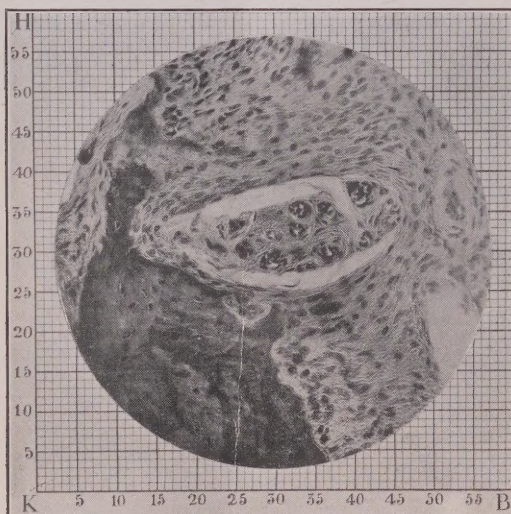


Fig. 52— x 375. Rarefying Pericementitis Fibrosa. Large mass of new tissue encroaching upon the crest of the alveolar process with the resultant absorption of a large portion of the crest. Note the tiny inlet below the mass of new tissue.

H K 40 x K B 12, Tip of the alveolar crest. H K 32 x K B 32, Large mass of new tissue. Note the numerous blood-vessels. H K 30 x K B 12, Base of excavation in alveolar bone. H K 22 x K B 26, Tiny inlet in alveolar surface.

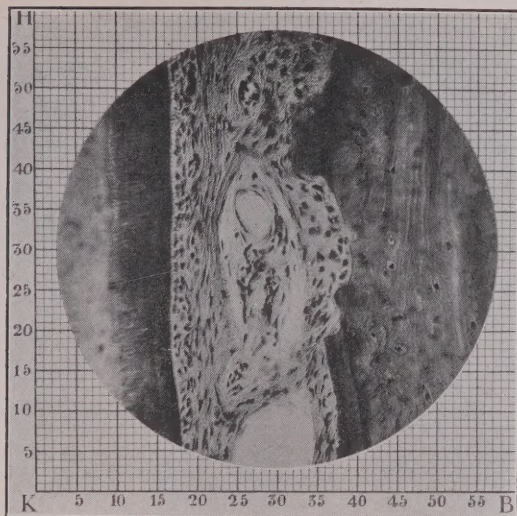


Fig. 53— x 375. Rarefying Pericementitis Fibrosa. Large mass of new tissue near the surface of the alveolar wall with typical excavation in the bone. Note the row of osteoblasts on the excavation border.
H K 25 x K B 30, Large mass of new tissue. H K 31 x K B 39, Base of excavation.

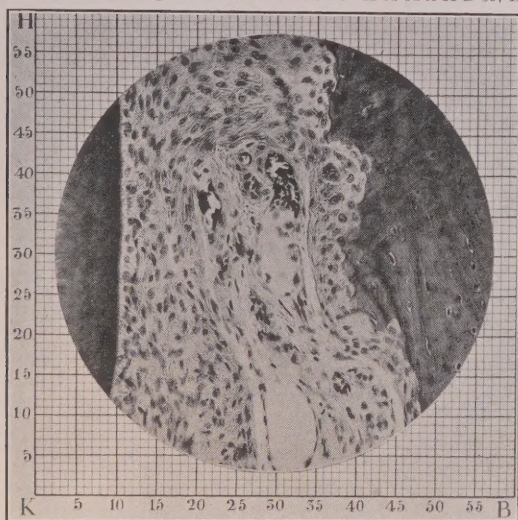


Fig. 54— x 375. Rarefying Pericementitis Fibrosa. Large irregular mass of new tissue near the surface of the alveolar bone. Note the eroded appearance of the bone surface.

- | | |
|------------------|---|
| H K 44 x K B 27, | Upper margin of irregular mass of new tissue. |
| H K 4 x K B 28 } | Lower borders of mass of new tissue. |
| H K 9 x K B 46 } | |
| H K 38 x K B 31 | |
| H K 14 x K B 38 | Blood-vessels in new tissue. |
| H K 40 x K B 40, | Base of excavation of bony surface. |
| H K 49 x K B 10, | Cemental border. |

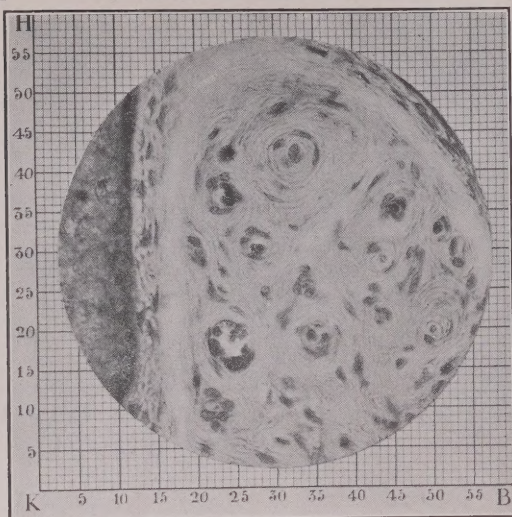


Fig. 55— x 750. Rarefying Pericementitis Fibrosa. High magnification of new tissue. Note proliferation of endothelial cells lining blood-vessels; also types of cells in new tissue surrounding the blood-vessels.

H K 43 x K B 33, Complete occlusion of blood-vessel lumen. H K 19 x K B 35, Partial occlusion of blood-vessel lumen. H K 30 x K B 20, Endothelial cells in the new tissue. H K 42 x K B 24, Plasma cell. H K 39 x K B 43, H K 37 x K B 30: Fibroblasts. H K 18 x K B 25, Large blood-vessel.

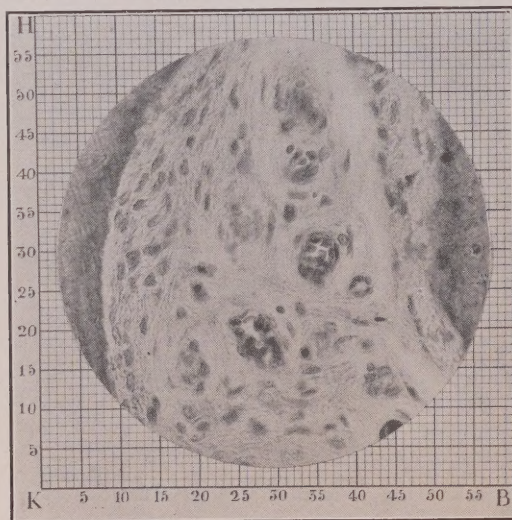


Fig. 56— x 750. Rarefying Pericementitis Fibrosa. High magnification of new tissue.

H K 48 x K B 33, Complete occlusion of blood-vessel lumen through proliferation of the endothelial cells. H K 40 x K B 34, Partial occlusion of blood-vessel lumen. H K 18 x K B 24, H K 12 x K B 25: Endothelial cells in new tissue. H K 28 x K B 20, H K 25 x K B 20, H K 17 x K B 34: Plasma cells. H K 23 x K B 30, Lymphocyte. H K 41 x K B 39, Fibroblast. H K 30 x K B 35, Large blood-vessel.

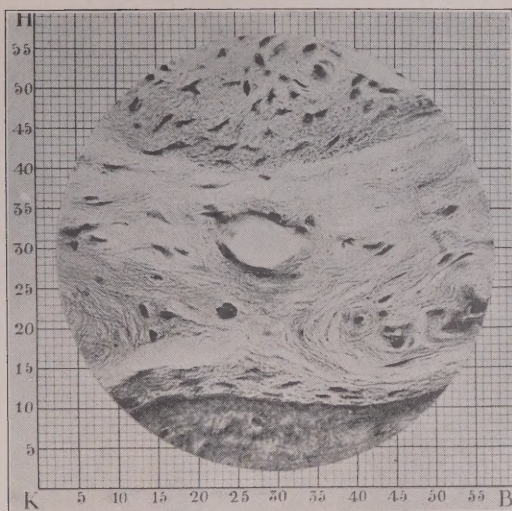


Fig. 57— x 750. Rarefying Pericementitis Fibrosa. High magnification of new tissue.

H K 23 x K B 23, Plasma cell in new tissue.

H K 21 x K B 40 } Lymphocytes in new tissue.

H K 22 x K B 43 }

H K 29 x K B 53 Fibroblasts in new tissue.

H K 16 x K B 45

H K 40 x K B 30, Margin of mass of new tissue. H K 45 x K B 30, Normal pericementum. H K 10 x K B 36, Surface of alveolar bone.

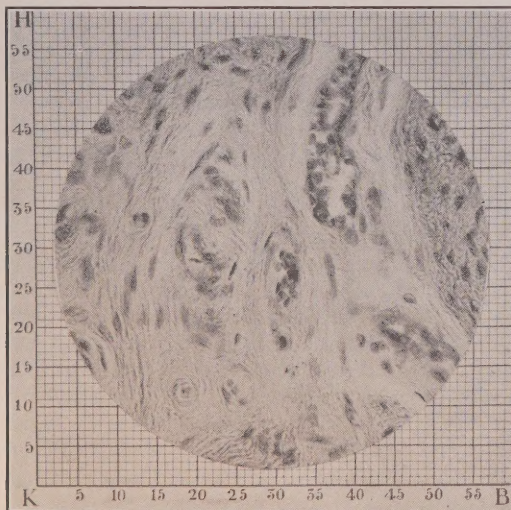


Fig 58— x 750. Rarefying Pericementitis Fibrosa. High magnification of new tissue.

H K 35 x K B 35, Large blood-vessel.

H K 20 x K B 45, Partial occlusion of blood-vessel lumen. Note the endothelial cells in the new tissue surrounding the same blood-vessel.

H K 35 x K B 24, Endothelial cells in the new tissue.

H K 31 x K B 29 Fibroblasts.

H K 27 x K B 25

H K 48 x K B 29, Lymphocyte.

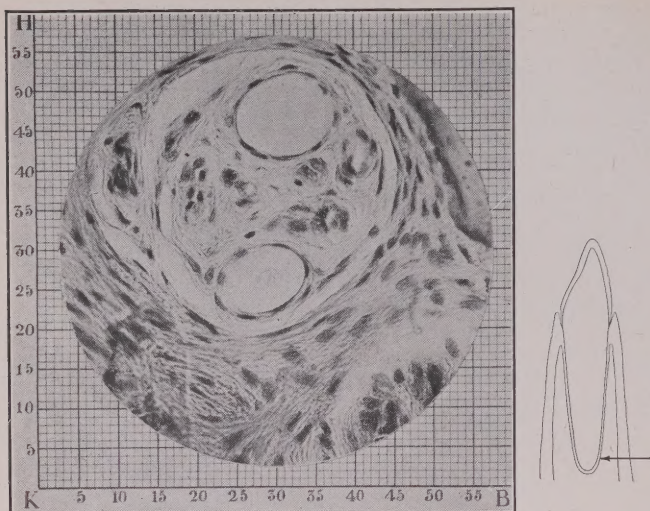


Fig. 59— x 750. Rarefying Pericementitis Fibrosa. High magnification of nodular mass of new tissue.

- H K 34 x K B 36, Partial occlusion of blood-vessel lumen.
 H K 38 x K B 11, Complete occlusion of blood-vessel lumen.
 H K 39 x K B 24, Plasma cell.
 H K 53 x K B 32, Fibroblast.
 H K 32 x K B 27, Lymphocyte.
 H K 33 x K B 33, Endothelial cell in new tissue.
 H K 15 x K B 25, Normal pericemental tissue.

The rarefaction of the alveolar process is the result of involvement, by the new tissue, of the osteogenetic tissue on the exterior of the bone, and the setting up of the mechanism of bone absorption. These areas are manifested by great cell activity. However, other areas of bone loss seem to be associated with nutritional disturbances caused by this new tissue, and atrophic changes follow in the bone. Starting with a fairly simple process, the final rarefaction of the bone is a complicated melting-down process.

As stated previously, the reaction around the blood-vessels, characterized by the presence of endothelial cells, along with occasional lymphocytes, plasma cells, and fibroblasts, is the prominent feature of this new tissue. Through increase in size of masses of this tissue lying in the body of the pericementum, or through proximity to the surface of the alveolar bone, of the blood-vessels manifesting the reaction, these same cells encroach upon the bony surface. Accompanied by osteoblasts and osteoclasts, the absorption of bone is seen to take place, with the formation of little bay-like depressions into the surface of the alveolar wall. Into these inlets, the new tissue extends in finger-like projections along the blood-vessels, carrying inwards reactions similar to those seen upon the surface, and producing within the bone an internal rarefaction (Figs. 60, 61).



Fig. 60— x 125. Rarefying Pericementitis Fibrosa. Alveolar rarefaction. Large bay-like depression in the alveolar wall. Note that it is filled with new tissue, an extension from the pericementum.

H K 30 x K B 15, Alveolar process. H K 7 x K B 23, Extremity of bay-like depression. H K 30 x K B 25, Large mass of new tissue. H K 50 x K B 33, Normal pericementum. H K 10 x K B 35, New tissue in pericementum. H K 54 x K B 41, Cemental border. H K 30 x K B 10, External surface of alveolar process.

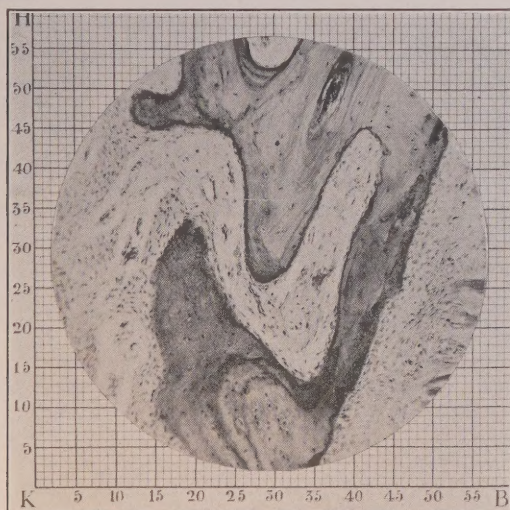


Fig. 61— x 125. Rarefying Pericementitis Fibrosa. Alveolar rarefaction. Large bay-like depression in the alveolar bone filled with new tissue which has replaced the bone by extension from the pericementum.

H K 30 x K B 5, Normal pericementum. H K 40 x K B 30, Alveolar process. H K 45 x K B 42, Extremity of large bay-like cavity. H K 20 x K B 35, New tissue filling depression. H K 25 x K B 46, External surface of alveolar process.

The rarefying process is frequently characterized, in its early stages, by the appearance at certain intervals along the wall of the alveolar bone, of fairly regular indentations formed by the encroachment of small nodular masses of new tissue (Figs. 62, 63, 64, 65).

Another typical feature is the appearance on the surface of the bone of irregular excavations, at the border of which is arranged a row of osteoblasts, each cell resting in a small concavity. In these larger excavations, masses of new tissue are to be seen (Figs. 66, 67).

Another characteristic of certain histological pictures is the presence of small transverse canals or channels with ragged walls, which frequently perforate the alveolar bone to a considerable distance from the surface. These small canals contain finger-like extensions of new tissue (Figs. 68, 69, 70, 71).

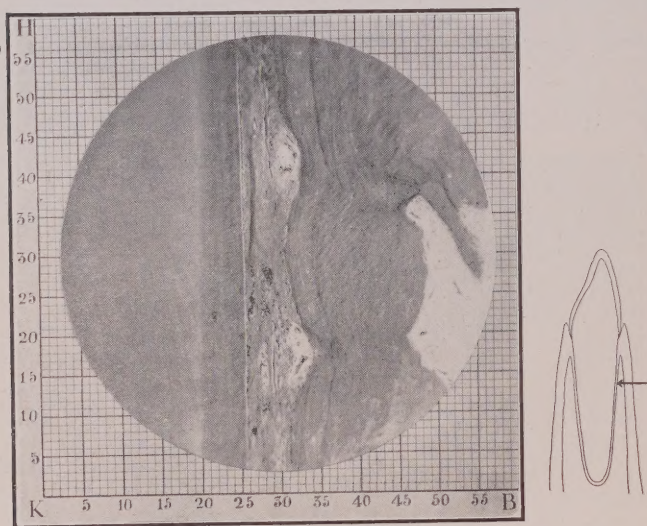


Fig. 62— x 94. Rarefying Pericementitis Fibrosa. Rarefaction of the alveolar process. Indentation.

H K 43 x K B 32 }
 H K 18 x K B 33 } Indentations of the inner wall of the alveolar process.
 H K 30 x K B 24, Cementum.

H K 30 x K B 28, Pericementum. Note that at this level the pericementum and cementum are of equal thickness.

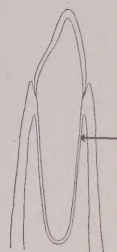
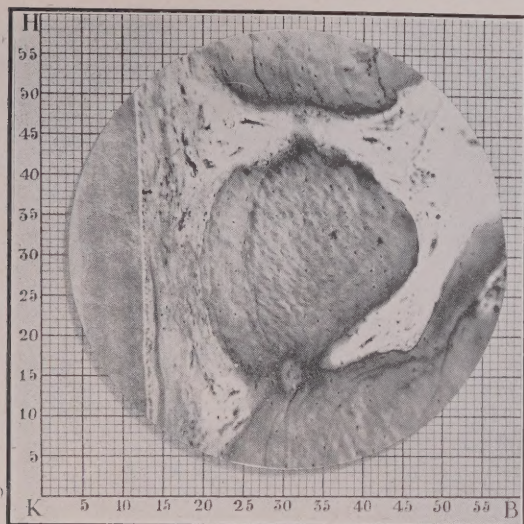


Fig. 63— x 125. Rarefying Pericementitis Fibrosa. Alveolar rarefaction. Indentation more advanced, leading to segmentation.

H K 33 x K B 35, Portion of alveolar bone in process of separation from adjacent bone. H K 14 x K B 27, H K 18 x K B 36: Indentation process tending to formation of continuous channel. H K 47 x K B 28, Indentation becoming a channel and thus producing segmentation of bone.

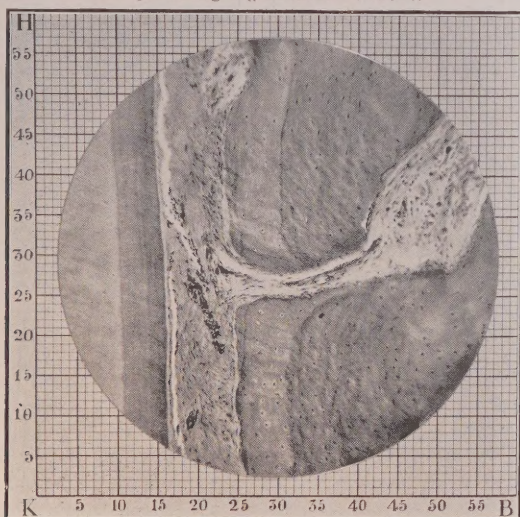


Fig. 64— x 125. Rarefying Pericementitis Fibrosa. Alveolar rarefaction. Channel produced as a result of the indentation process.

H K 54 x K B 24, Early indentation. H K 28 x K B 28, Channel formed through indentation process. H K 26 x K B 20, H K 34 x K B 18: Blood-vessels of pericementum much dilated. H K 15 x K B 14, Cementum. H K 15 x K B 22, Pericementum.

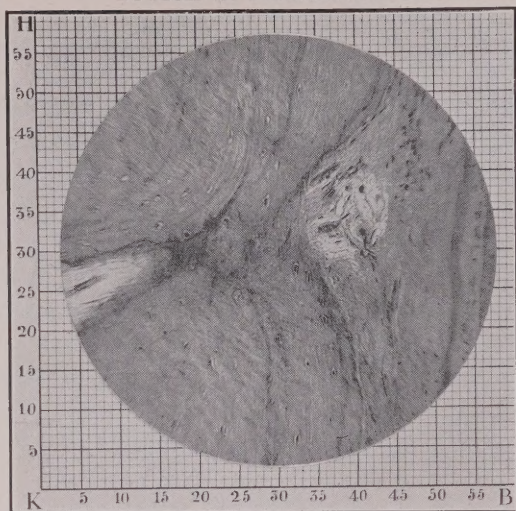


Fig. 65— x 375. Rarefying Pericementitis Fibrosa. Alveolar rarefaction. Indentation. Another example of the tendency of the indentation process to form channels through the alveolar bone.

H K 30 x K B 15 } Indentations.

H K 35 x K B 35 }

H K 30 x K B 52, Cemental surface. H K 30 x K B 48, Pericementum.

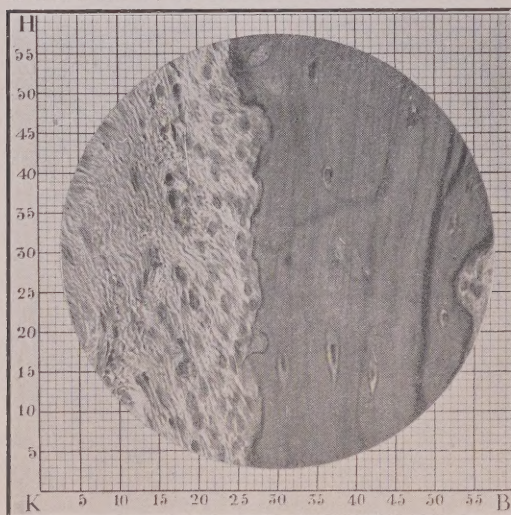


Fig. 66— x 500. Rarefying Pericementitis Fibrosa. Alveolar rarefaction. Excavation of the surface of the alveolar bone. A layer of osteoblasts is lying in close adaptation to the surface of the bone, which is undergoing absorption.

H K 49 x K B 25 to H K 18 x K B 27. This shows an irregular border, due to absorption. H K 30 x K B 25, H K 26 x K B 26: Osteoblasts. H K 18 x K B 37, Bone cell in lacuna.

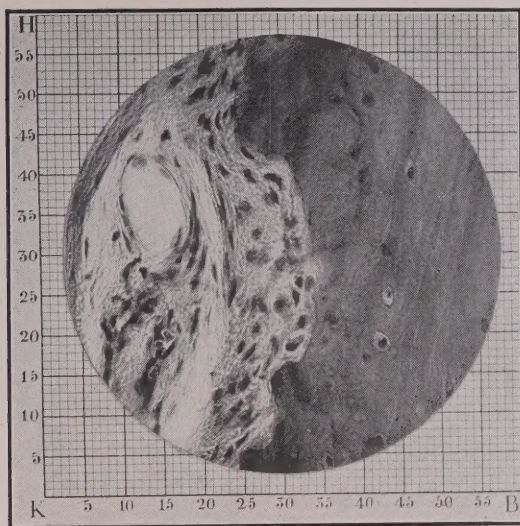


Fig. 67—x 500. Rarefying Pericementitis Fibrosa. Alveolar rarefaction. Excavation on the surface of the alveolar border.

H K 44 x K B 25 to H K 6 x K B 25, Large, irregular excavation. H K 19 x K B 31, Osteoblast. H K 35 x K B 14, Blood-vessel in pericementum.

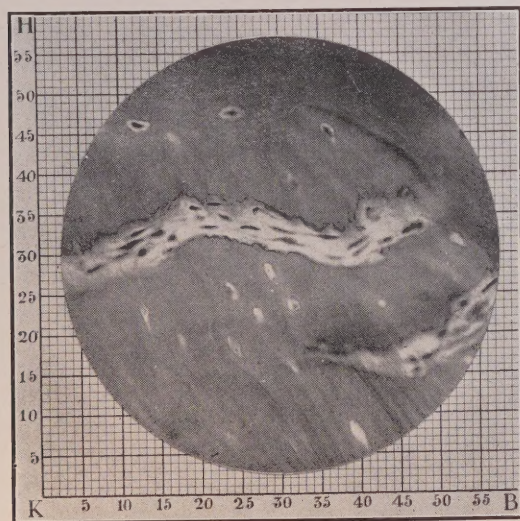


Fig. 68—x 500. Rarefying Pericementitis Fibrosa. Alveolar rarefaction. Perforating canals.

H K 35 x K B 18 } Perforating canals penetrating alveolar bone trans-
H K 18 x K B 48 } versely to the lamellae.
H K 33 x K B 31 } New tissue.
H K 37 x K B 47, Bone-cell and lacuna undergoing absorption.

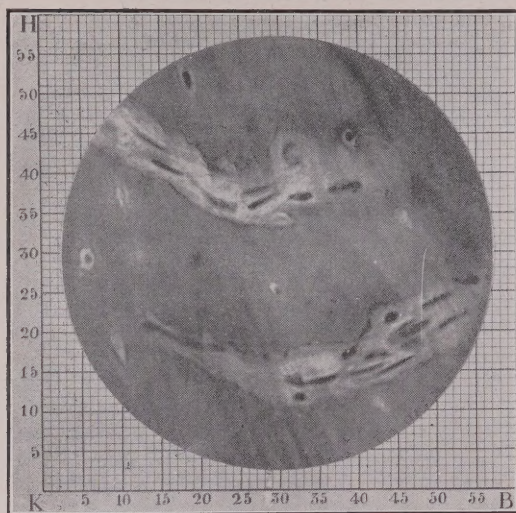


Fig. 69—x 750. Rarefying Pericementitis Fibrosa. Alveolar rarefaction. Perforating canals.

H K 43 x K B 36 } Terminations of perforating canals.
 H K 20 x K B 16 }
 H K 38 x K B 28, New tissue.
 H K 45 x K B 39, Bone-cell and lacuna undergoing absorption.

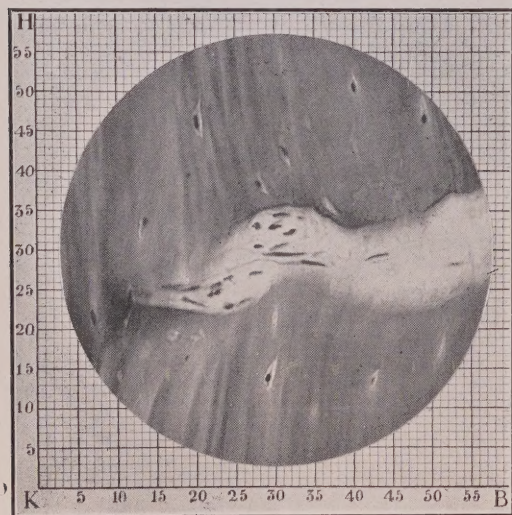


Fig. 70—x 500. Rarefying Pericementitis Fibrosa. Alveolar rarefaction. Perforating canal.

H K 30 x K B 40, Perforating canal.
 H K 29 x K B 32, New tissue.
 H K 35 x K B 31, Osteoblast.
 H K 14 x K B 29, Bone-cell in lacuna.

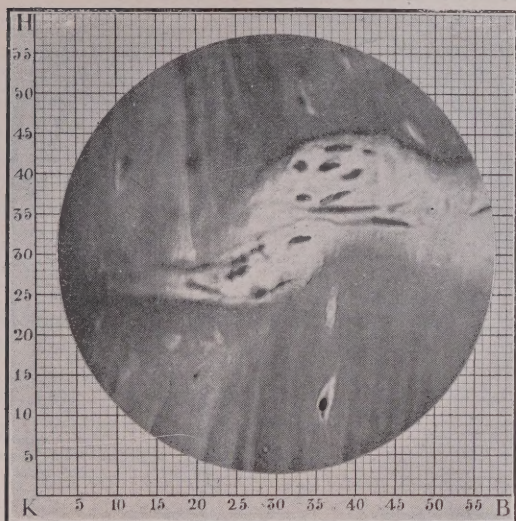


Fig. 71—x 750. Rarefying Pericementitis Fibrosa. Alveolar rarefaction. Perforating canal. High magnification of the specimen shown in the previous illustration.

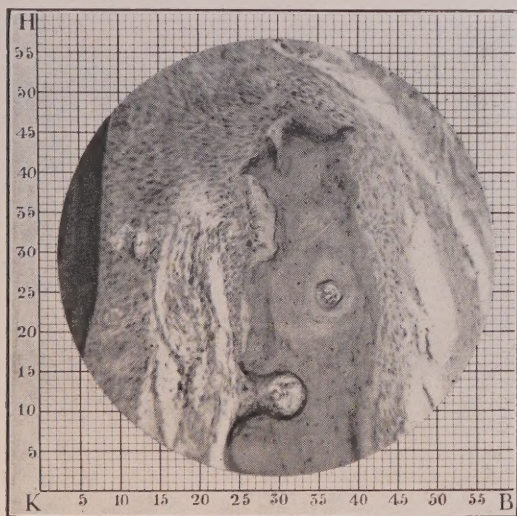


Fig. 72—x 125. Rarefying Pericementitis Fibrosa. Alveolar rarefaction. Nutritional atrophy.

- | | |
|------------------|--|
| H K 47 x K B 30, | Zone of osteoid tissue at the crest of the alveolar. |
| H K 35 x K B 28 | } Osteoid zones along the inner wall of the alveolar bone. |
| H K 22 x K B 25 | |
| H K 25 x K B 37, | Haversian canal. |
| H K 30 x K B 7, | Cementum. |
| H K 45 x K B 20, | Pericementum. |

In addition to these typical phases, and in frequent and varied association with them, there are certain zones in which the bone changes its character to an osteoid tissue. These zones are found on the surface of the bone and in the Haversian canals. The bony structure stains unequally, dependent upon the amount of constituent elements in the matrix. Pale pink-staining matrix takes the place of the calcified tissue, which is blue in its reaction with hematoxylin, and there is a loss of the bone-cells. These atrophic changes appear to be associated with nutritional disturbances caused by the new tissue (Figs. 72, 73, 74, 75, 76).

Other osteoid zones are to be noted, and they are regarded as regions showing bone-formation, in which the ground substance laid down by the osteoblasts is, as yet, calcium-free.

A minor phase of the rarefying process is the thinning of the bony lamellae by the coalescence of pit-like depressions, Howship's lacunae, which have been formed by the action of the multinuclear giant-cells, the so-called osteoclasts (Figs. 77, 78, 79, 80, 81).

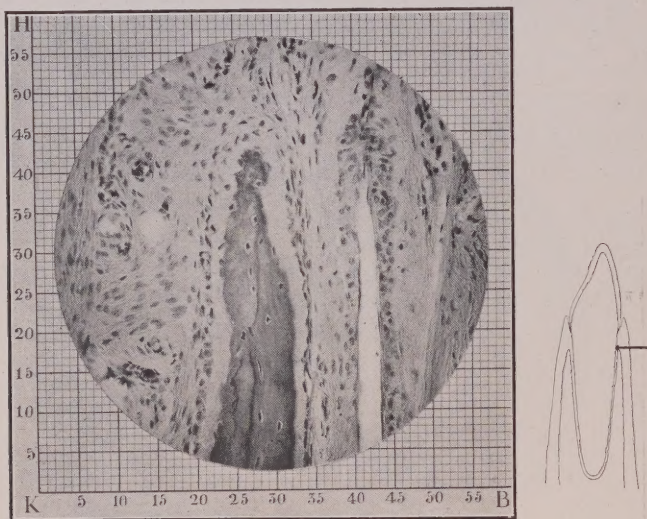


Fig. 73—x 375. Rarefying Pericementitis Fibrosa. Alveolar Rarefaction. Atrophy due to nutritional disturbance caused by the new tissue.

- | | |
|------------------|--|
| H K 45 x K B 28, | Crest of alveolar process. |
| H K 5 x K B 20 | } Borders of the alveolar process. |
| H K 3 x K B 34 | |
| H K 35 x K B 30 | } Osteoid tissue bordering the alveolar crest. |
| H K 44 x K B 28 | |
| H K 19 x K B 23 | |
| H K 32 x K B 22, | Border of osteoid tissue. |
| H K 32 x K B 24, | Border of calcified tissue. |
| H K 32 x K B 29, | Border of calcified tissue. |
| H K 32 x K B 32, | Border of osteoid tissue. |
| H K 17 x K B 15, | Mass of new tissue in pericementum. |

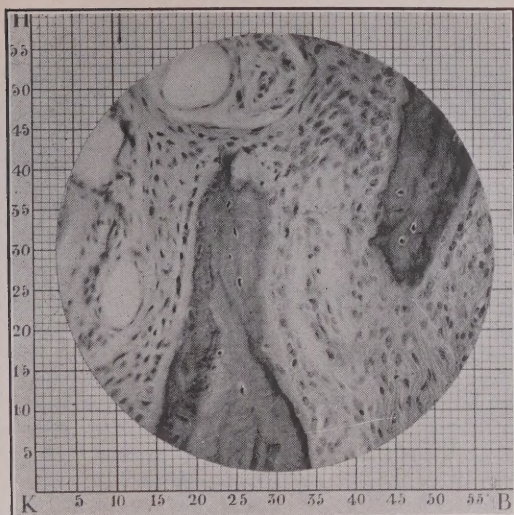


Fig. 74—x 375. Rarefying Pericementitis Fibrosa. Alveolar Rarefaction. Nutritional atrophy.

- H K 43 x K B 25, Tip of segment of alveolar bone.
 H K 40 x K B 27 } Osteoid tissue.
 H K 18 x K B 30 }
 H K 50 x K B 30 } Masses of new tissue in the pericementum.
 H K 20 x K B 10 }
 H K 25 x K B 45, Base of a segment of alveolar bone.

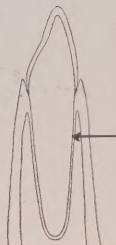
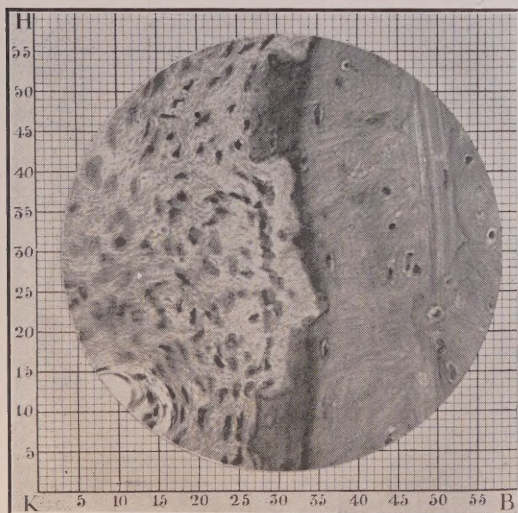


Fig. 75—x 500. Rarefying Pericementitis Fibrosa. Alveolar Rarefaction. Nutritional atrophy.

- H K 28 x K B 32, Osteoid zone along the inner wall of the alveolar process.
 H K 35 x K B 29, Row of osteoblasts along the border of the calcium-free zone.

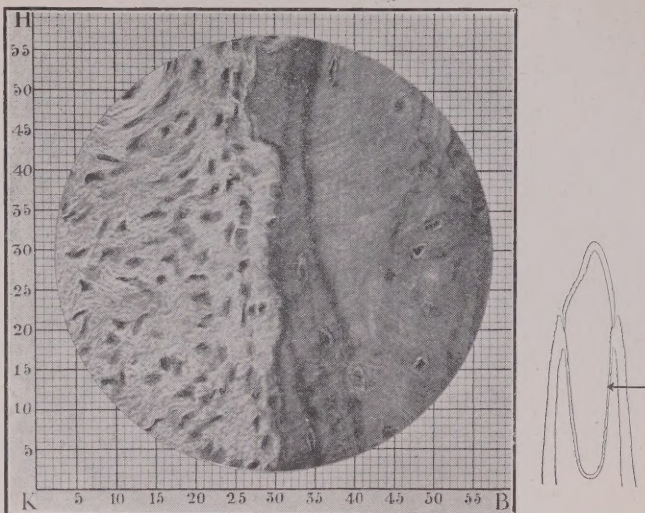


Fig. 76—x 750. Rarefying Pericementitis Fibrosa. Alveolar Rarefaction. Osteoid zone along the inner surface of the alveolar process.

H K 38 x K B 29, Osteoid zone. H K 34 x K B 25, Row of osteoblasts on the border of the calcium-free bone.

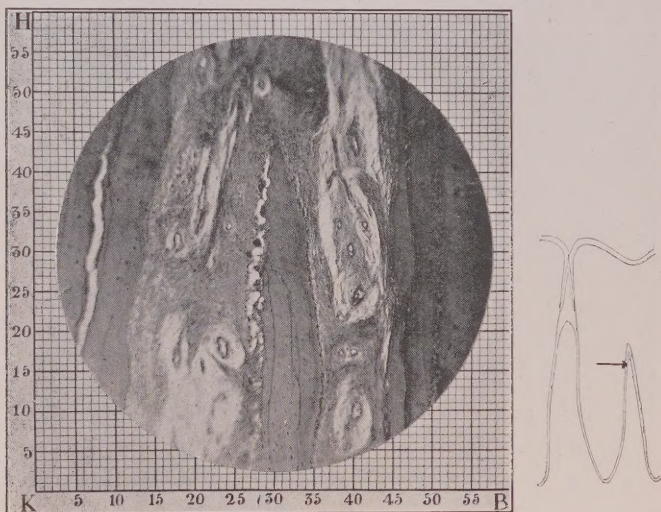


Fig. 77—x 94. Rarefying Pericementitis Fibrosa. Alveolar Rarefaction. Osteoclastic absorption. This section shows the bone in the bifurcation of a lower molar.

H K 45 x K B 30, Crest of alveolar bone.
 H K 31 x K B 28, Osteoclast in Howship's lacuna.
 H K 30 x K B 23 }
 H K 30 x K B 40 } Pericementum.
 H K 30 x K B 12 }
 H K 30 x K B 45 } Cementum.

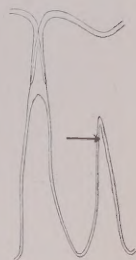
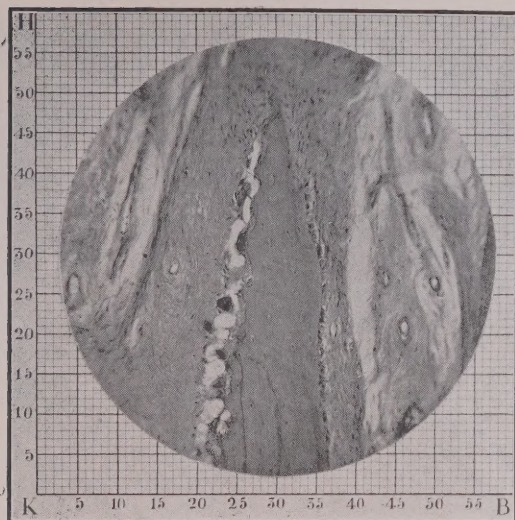


Fig. 78—x 188. Rarefying Pericementitis fibrosa. Alveolar Rarefaction. Osteoclastic absorption. Higher magnification of the specimen shown in the preceding illustration.

H K 24 x K B 23, Osteoclast.

H K 47 x K B 30, Crest of alveolar process.

H K 23 x K B 35, Row of osteoblasts.

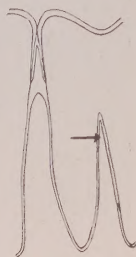
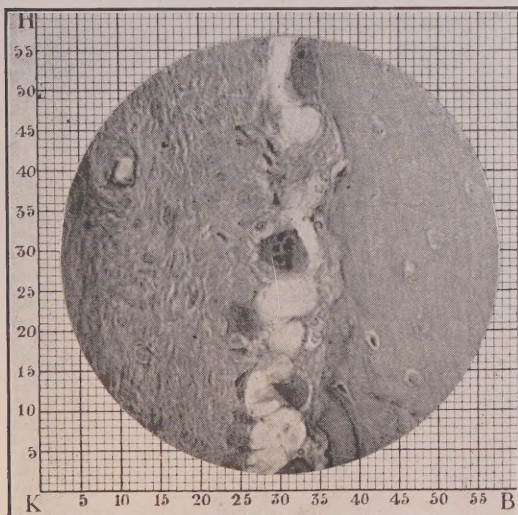


Fig. 79—x 500. Rarefying Pericementitis fibrosa. Alveolar Rarefaction. Osteoclastic absorption.

H K 30 x K B 30, Osteoclast.

H K 28 x K B 37, Howship's lacuna.

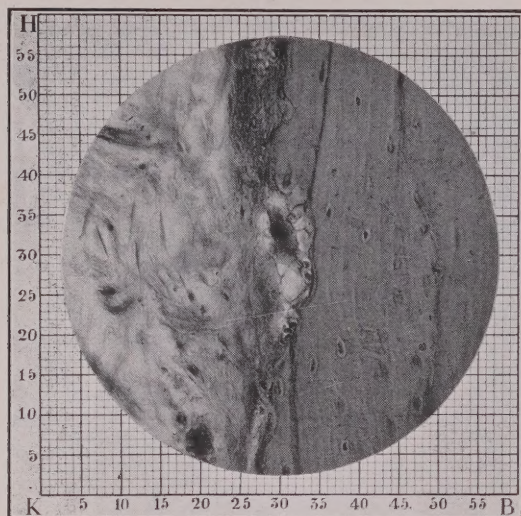


Fig. 80— x 500. Rarefying Pericementitis Fibrosa. Alveolar Rarefaction. Osteoclastic absorption.

H K 34 x K B 30, Osteoclast.

H K 32 x K B 34, Howship's lacuna.

H K 30 x K B 15, Pericementum.

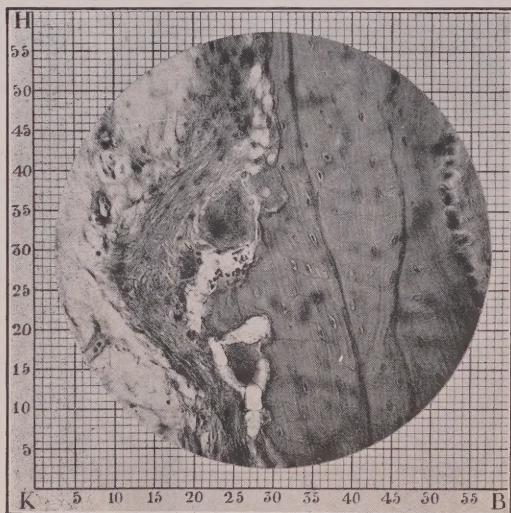


Fig. 81— x 375. Rarefying Pericementitis Fibrosa. Alveolar Rarefaction. Osteoclastic absorption.

H K 33 x K B 24 } Osteoclasts.

H K 16 x K B 26 }

H K 30 x K B 15, Pericementum.

Following upon these peculiar and characteristic changes taking place upon the surface of the bony trabeculae, wherein a specific type of reaction leads to the development of perivascular nodules, as well as of excavations of the bone, there develops a new tissue essentially composed of fibrous connective tissue, and which tends to replace the normal structure of the bone-marrow. This fibrosis is laid down in an orderly fashion, and, during its growth, is not accompanied by the cells of the inflammatory exudate, nor by new capillaries such as are found in the development of true granulation tissue. The fibrous tissue, which appears in the marrow-spaces, develops as a hyperplasia, or it may be in response to a very mild and unknown stimulus, providing a proliferation of this tissue without inducing characteristic changes in the other structures. This fibrous tissue growth is so gradual and uniform that some have been inclined to regard it, in relation to disease of bone in other parts, as a type of reaction lying between inflammation, on the one hand, and new-growth, on the other. Much comment has been made in the literature concerning Osteitis Fibrosa of the long bones. In our studies, a similar reaction was found in the alveolar process, as well as in the pericementum, which we believe must be studied in parallel relation to that of other bones. Figs. 82, 83, 84.

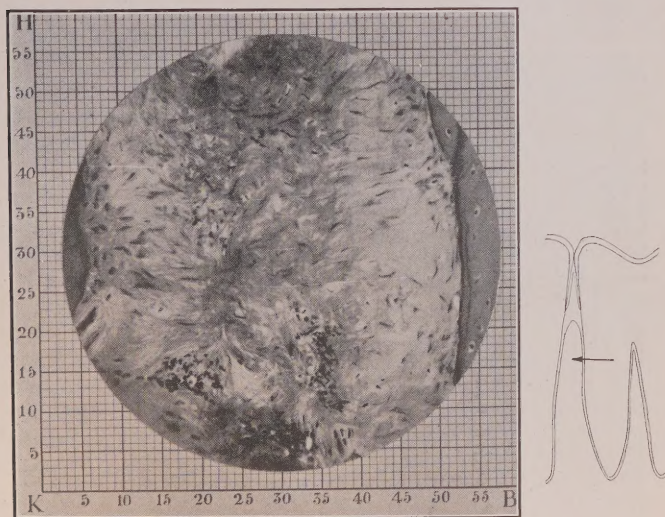


Fig. 82—x 375. Rarefying Pericementitis Fibrosa. Fibrosis of marrow-space.

H K 30 x K B 5 } Alveolar bone.
H K 30 x K B 55 }

Note numerous fibroblasts in intervening soft tissue.

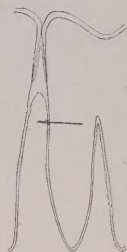
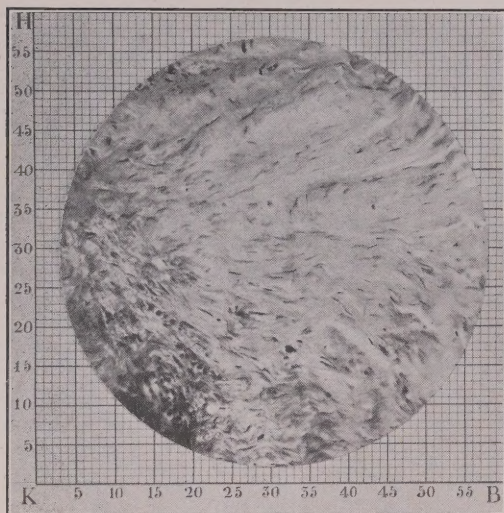


Fig. 83— x 375. Rarefying Pericementitis Fibrosa. Fibrosis at alveolar-margin.

H K 25 x K B 40 } Bundles of connective-tissue fibres.
H K 42 x K B 45 }

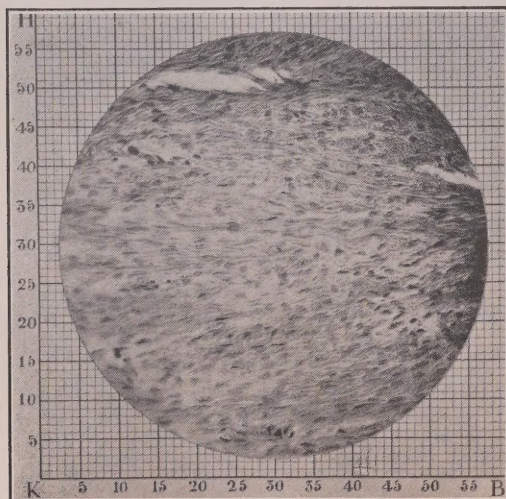


Fig. 84— x 375. Rarefying Pericementitis Fibrosa. Fibrosis subsequent to absorption of alveolar bone.

H K 32 x K B 35 } Connective-tissue fibres.
H K 10 x K B 40 }

In the disease, Rarefying Pericementitis Fibrosa, the inflammatory changes noted in the gingival tissues are found to be extremely superficial, and they bear no relation to the changes that are observed in the pericementum. Furthermore, it is to be recognized that a varying infiltration by lymphocytes and plasma cells is constantly encountered in *normal* conditions in the mouth and surrounding parts. These inflammatory reactions vary from time to time, and seem to be found frequently in response to mild superficial irritations from foodstuffs and temperature changes.

The lesions of Rarefying Pericementitis Fibrosa localize themselves most often in the periodontal tissues of teeth which are in traumatic occlusion, or over-function, and appear to originate in pericemental tissues which are frequently subjected to abnormal occlusal stress.

Any tooth under occlusal stress, and acted upon by forces in equilibrium, presents to us the ideal picture of physiological occlusion. While physiological occlusion is based upon a mechanical equilibrium, that is, a condition in which the force of resistance offered by the alveolar process is equal to the occlusal stress directed through the tooth, the force of resistance maintained by the alveolar bone is probably dependent upon a state of equilibrium existing between the calcium content of the bone and the calcium content of the blood. It has been demonstrated by Wells that the calcium salts in bone are in a condition of flux, and that, if the body requires increased calcium, as during pregnancy, these calcium salts can be drawn upon. While occlusal traumatism seems to serve as the main factor in the localization of the lesions of Rarefying Pericementitis Fibrosa, certain conditions, in which the body is being robbed of its normal supply of calcium, seem, from a clinical standpoint, to accelerate the process of rarefaction.

When Rarefying Pericementitis Fibrosa is manifested as a pure type of periodontal disease, the phenomenon is usually observed in which there is a parallelism between alveolar resorption and gingival recession; in other words, recession of the gingival tissue making parallel progress with the bone resorption. The parallelism may be disturbed, however, by the establishment of infection in the gingival tissues. With the evolution of a superimposed, infective periodontitis, through consequent pocket formation, there is brought about the pathological composite, Chronic Periodontitis, Complex, to be described later. And there is much evidence to support the viewpoint that in the production of this infective periodontitis, of paramount importance as a causative factor, is the primary establishment of the disease, Rarefying Pericementitis Fibrosa.

The typical sites in the alveolar process of the rarefying phase of this disease are as follows: First, the parietal wall of the alveolus;

second, the crests of the alveolar process, including the process between the roots of bicuspid and molars; third, the crests, together with the periapical bone (the tooth situated in its alveolus furnishes a good example, in many instances, of a lever of the second class); and, fourth, the periapical bone.

The importance of early diagnosis of Rarefying Pericementitis Fibrosa cannot be over-emphasized. The primary lesion consists in the formation in the pericementum, of a new and pulp-like tissue, which replaces the normal pericemental structures, with interference of their normal functions. This is often manifested clinically by a slightly increased mobility of the tooth in its alveolus, due probably to the peculiar yielding character of the new tissue. The process of rarefaction, initiated by the new tissue, is frequently first manifested clinically by an increased radiolucency of the alveolar crest and associated osseous tissue. In other words, the crests of the alveolar bone become less impervious to the X-rays. This is followed by a change in the contour of these crests and a disturbance of their normal position, as related to the gingival line—the amelo-cemental junction. It is unsafe, however, to place entire dependence on the radiograph, since labial crest absorption may take place without registering on the X-ray negative. In such a case, careful examination of the relationship existing between the margin of the gingival tissue and the amelo-cemental line should be made. In the average normal case, the margin of the gingiva is approximately two millimeters above the amelo-cemental line. Also, the crest of the alveolar process in the average normal case is approximately two millimeters below this fixed landmark. Recession of the marginal gingiva is usually indicative of alveolar crest resorption. For example, a recession of the marginal gingiva which just exposes the amelo-cemental line will probably indicate a crest resorption of two millimeters. Exposure of the cementum will indicate an increased alveolar resorption of a corresponding degree.

The rarefying process frequently becomes initiated in the inner wall of the alveolar bone. In these instances, it is first manifested, radiographically, in certain zones, by an increased radiolucency of the lamina dura. Through progression of the process of rarefaction, by extension of the new tissue, the lamina dura is destroyed. This alveolar loss is usually apparent in the radiograph, and there is thus exhibited a definite widening of the normal pericemental space. Through consequent thickening of the soft tissue content between the tooth and the bone, there is a further increase in the mobility of the tooth in its alveolus. Divergence from normal mobility, being dependent, as a rule, upon profound structural changes in the pericementum and alveolar bone, must be regarded as a diagnostic sign of the first importance.

PART IV: PERIODONTITIS.

The term periodontium is used to designate the supporting tissues of the teeth. The three essential tissue-components of the periodontium are, the gingivae, the pericementum, and the alveolar process. By the term periodontitis, is denoted an inflammation of the periodontium and a disease so designated involves all three components. On this distinct basis, the term makes for simplification and accuracy in terminology. It excludes certain lesions of the periapical tissues, such as abscesses and granulomata, because, while the pericementum and alveolar process are involved in these lesions, the gingivae are not.

Based on clinical and histo-pathological findings, inflammation of the periodontium may be classified as follows:

1. Acute Periodontitis (fuso-spirillary)
2. Chronic Periodontitis, Simplex { with pocket
without pocket
- Complex { with pocket
without pocket

From pathological and clinical viewpoints, Chronic Periodontitis, of the pocket-producing types, may be divided, as seen in the foregoing classification, into two main divisions, first, the Simplex, and second, the Complex. Either type of Chronic Periodontitis, however, is the resultant of certain preceding lesions which, by their coalescence, constitute a distinct pathologic composite.

The order in which these lesions occur in the mature form of the Simplex type is as follows:

1. Chronic Gingivitis, Cemental (pocket in cemental gingiva).
2. Infective Osteitis (Rarefying and Condensing).
3. Chronic Pericementitis (pocket extension into the pericementum).

In the mature form of the Complex Periodontitis there are to be found two principal lesions:

1. Rarefying Pericementitis Fibrosa.
2. Infective Periodontitis.

Infective Periodontitis is in its turn made up of three constituent lesions which have appeared as phases in the following order:

- A. Chronic Gingivitis Cemental (pocket in cemental gingiva).
- B. Chronic Pericementitis (pocket extension into the pericementum).
- C. Infective Osteitis (Rarefying and Condensing).

The pocket which is exhibited in Chronic Gingivitis, Cemental, and Chronic Pericementitis, may be produced in two entirely different ways, although its histo-pathology is essentially the same in both types. Chronic Pericementitis is a common pathological factor in both the Simplex and Complex types of Periodontitis and manifests the same sequence of pathological changes.

In the Simplex type, the gingival lesion is the dominating one, and is not so extensive or rapid in pocket development as in the Complex type. It represents a simple reaction to bacterial invasion, whereby, through local lowered resistance in the gingival tissues, infection has been established. Consequent upon the loss of gingival attachment, absorption of the alveolar crest takes place, again an inflammatory reaction to toxic agents. In the majority of cases in which superficial causes are the dominating ones, progress is fairly slow, because of the fact that the pericementum is high in resistance.

In the Complex type of Chronic Periodontitis the formation of the pocket is a phenomenon preceded by much more complicated and profound changes than occur in a simple gingivitis. The ideal requirements for rapid and deep pocket extension are alveolar resorption, lowered resistance in part or all of the pericementum, and the establishment of gingivitis. Disturbance of equilibrium, as manifested in excessive function or traumatic occlusion, while but one etiological factor in the production of the required changes in the pericementum and alveolar process, is the most important one.

In the Periodontitis, Simplex, which, in its mature state, simulates the Complex, the progression is centripetal, while in the Complex type, the course is in the main, centrifugal. In other words, in both the Simplex and Complex types, the inflammation, subsequent to the establishment of infection, progresses *from without inwards*. But in the Complex type, the establishment of infection is subordinate to the lesion Rarefying Pericementitis Fibrosa, which has, as a rule, preceded it. By the fact of this sequence the indication is that the pathologic progression in the Complex Periodontitis is, in the early stages, *from within outward*.

HISTO-PATHOLOGY OF THE BASIC LESIONS OF CHRONIC PERIODONTITIS, COMPLEX.

RAREFYING PERICEMENTITIS FIBROSA.

We have previously stated that Chronic Periodontitis, Complex, is a disease produced through the coalescence of two distinct lesions, Rarefying Pericementitis Fibrosa and Infective Periodontitis. We have also stated that Infective Periodontitis is in its turn a composite of three lesions. We next proceed to a consideration of the nature of these lesions and their relationship to each other.

In stating that rarefaction of the alveolar process, as a rule, precedes gingivitis, in the type of periodontitis we choose to term Chronic Periodontitis, Complex, the researches of Hopewell-Smith, Roy, Gottlieb, Fleischmann and the writer have met on common ground.

These investigators state, however, that the primary lesion is a *marginal alveolar atrophy*, while our findings have led to the conclusion that the primary pathological change is a *chronic and progressive lesion of the pericementum*, which results in the rarefaction and destruction of the alveolar bone.

That true atrophic changes in the alveolar process can occur is not denied. Excellent examples can be seen about teeth that have become functionless during natural life. In other words, the enforced rest has brought about a true atrophy. In the mouth, a condition is frequently seen which is characterized by an entire absence of occlusal contact of certain teeth, from the time of their eruption, no matter what position the mandible assumes. This furnishes another example of lack of function, which brings about, sooner or later, atrophic changes in the periodontal tissues. These changes are dependent upon defective nutrition, as normal nutrition of the alveolar process and pericementum depends largely upon normal function of the teeth supported. Senile changes also depend, in part, upon defective nutrition of the tissues owing to changes in the blood-vessels which occur almost regularly with advanced age.

While insisting upon a most exact consideration of the histopathological findings the clinical observations of prominent periodontists cannot be overlooked. There is sufficient clinical evidence to prove that rarefaction of the alveolar process is almost constantly associated with over-functioning teeth. The splendid work of Stillman and McCall has brought to the attention of the profession, in a way not heretofore shown, the injurious effects of over-function upon the periodontal tissues, as manifested in traumatic occlusion. Traumatic occlusion seems to serve as the main factor in the localization of this rarefying process.

The type of rarefaction of the alveolar process, most commonly found, is a phase of a complex disease condition termed by the writer Rarefying Pericementitis Fibrosa. It is to be kept in mind that the important, though not the spectacular element in this disease, is the formation in the *pericementum* of a new tissue which has previously been described. The histo-pathology of this disease has been given in detail in an earlier part of this paper.

✓ INFECTIVE PERIODONTITIS.

Infective Periodontitis, as previously stated, is a composite disease produced by the coalescence of Chronic Gingivitis (cemental), Chronic Pericementitis and Infective Osteitis. These three lesions

occur in a sequential relationship and may be regarded as phases in the development of Infective Periodontitis. The relationship between Rarefying Pericementitis Fibrosa and Infective Periodontitis is a very important one. Were it not for the primary establishment of Rarefying Pericementitis Fibrosa, the Infective Periodontitis would establish itself as a Chronic Periodontitis, Simplex, a disease characterized by slow progression, shallow pocket formation, and little divergence from normal mobility in the early stages.

The difference between Chronic Periodontitis, Simplex, and Chronic Periodontitis, Complex, as observed clinically is most spectacular. In the Complex type, the prominent characteristics are: rapid development of the periodontitis, the formation of a deep and narrow pocket, and marked divergence from normal mobility.

In this latter type, the Rarefying Pericementitis Fibrosa is not only the primary lesion, as regards pathological progression, but it is actually a causal lesion in the production of Infective Periodontitis, and having once brought about the establishment of Chronic Periodontitis, Complex, the Rarefying Pericementitis Fibrosa remains, in many cases, the dominating lesion of the composite. This lesion is causal in that, in part, it provides the requisites for the establishment of infection in the gingivae and its progression into the deeper structures.

PHASE 1. CHRONIC GINGIVITIS—*Cemental*.

Cemental-gingival pocket.

A cemental-gingival pocket is a lesion occurring at the base of the gingival crevice, whereby a certain amount of separation of the tissue of the cemental gingiva from the cementum has taken place.

The cemental gingiva is that division of the gingivae which rests upon and is supported by the crests of the alveolar process. It is attached to the cementum from the level of these crests to the amelocemental junction. This tissue in turn supports the marginal gingiva, which by its apposition with the enamel forms the gingival crevice. It will be recalled that its circulation is derived in part from the pericementum, in part from the alveolar mucosa. Its circulation is also continuous with that of the marginal gingiva. It is subject to circulatory disturbance arising in either the pericementum or marginal gingiva. This fact together with its proximity to the gingival crevice which so frequently contains pathogenic bacteria, renders this tissue peculiarly susceptible to infection.

When infection takes place in the cemental gingiva, it usually occurs at the base of the gingival crevice, where through imperfect junction of the epithelial cells with the cementum or because of the extreme thinness of this defensive covering, invasion of the underlying connective tissue by bacteria is readily accomplished. Under the

microscope, the tissue in this locality exhibits infiltration by plasma cells and lymphocytes, which seem to be the predominating leukocytes in this lesion. These infections are therefore, as a rule, of the sub-acute type.

Because of the fact that these lesions are usually initiated as sub-acute inflammations, the classic signs of acute inflammation are lacking. This most important pathological process is therefore extremely difficult to diagnose clinically, until sufficient separation from the cementum has occurred to permit of measurement by the probe.

It will be recalled that we are considering a process which is leading toward a separation of the tissue of the cemental gingiva from the cementum. This separation which creates the so-called pocket, results in a denudation of the cementum. A striking feature of this process is the role played by the epithelium at the base of the gingival crevice. This epithelium exhibits a very constant tendency to proliferation and extension apically. The pocket is usually formed in one of two ways. Either the epithelium extends for some distance along the cemental surface, and subsequently becomes separated from it (figs. 85, 86 and 87); or by a progression of the inflammatory process, ulceration is established, with a consequent denudation of the cementum. In the first instance, ulceration occurs, if at all, as a secondary phenomenon to

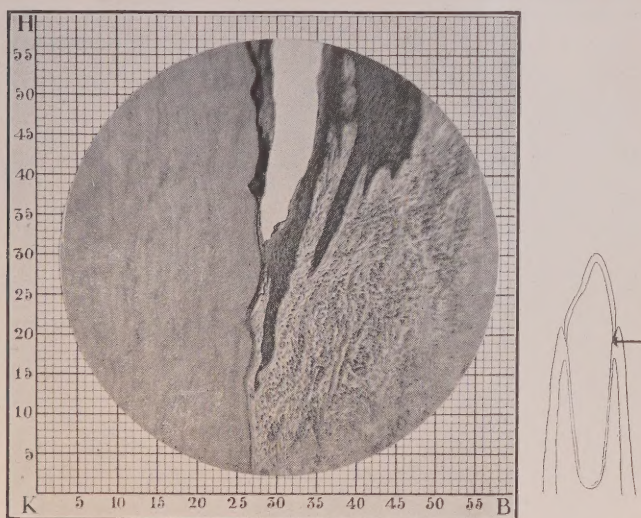


Fig. 85— x 125. Early proliferation and extension of crevicular epithelium at the base of the gingival crevice. Tissue change leading to the formation of a pocket in the cemental gingiva.

H K 32 x K B 28, Base of gingival crevice.
H K 19 x K B 29, Proliferating epithelium.
H K 19 x K B 35, Leukocytic infiltration.

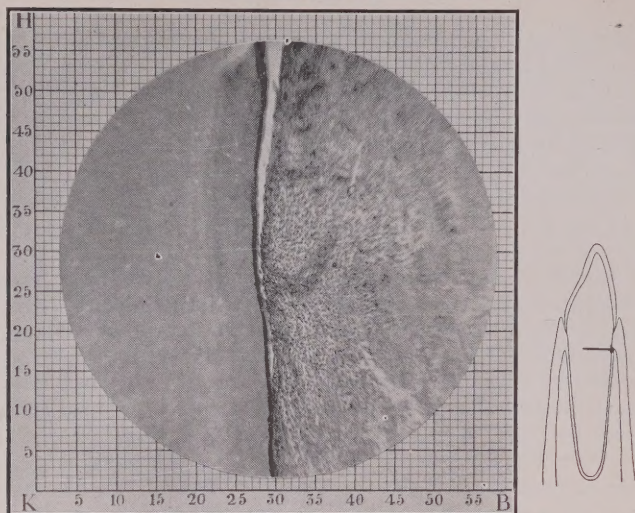


Fig. 86— x 125. Deep extension of proliferating epithelium along the cementum and beginning separation. Early pocket formation in the cemental gingiva.

H K 4 x K B 30, Extremity of proliferating epithelium.

H K 15 x K B 30, Base of newly-formed pocket.

H K 33 x K B 32, Leukocytic infiltration. Note that alveolar bone has been absorbed in advance of the extension of the pocket. The original position of the crest of the alveolar process was probably H K 14 x K B 36.

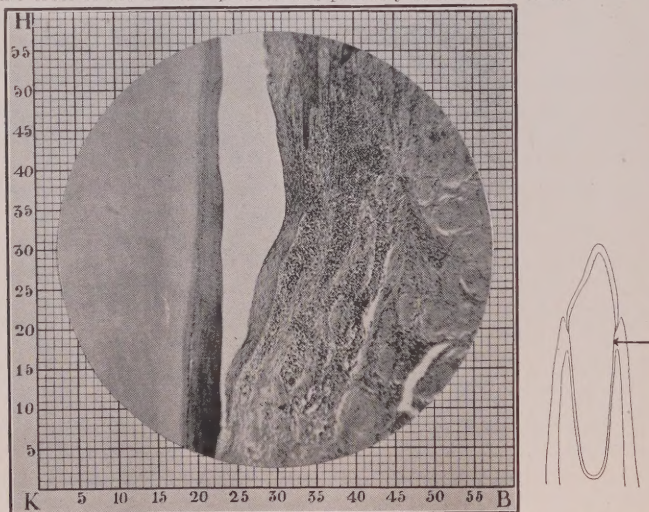


Fig 87— x 94. Cemental-gingival pocket. Fully-formed pocket, showing the epithelial covering of the detached soft tissues.

H K 9 x K B 23, Base of pocket.

H K 25 x K B 28, Epithelial covering of soft tissues.

H K 30 x K B 37, Leukocytic infiltration.

H K 20 x K B 23, Cemental surface.

the tissue separation. In the second instance, tissue separation takes place primarily through the ulcerative process (figs. 88 and 89). In this latter case, any proliferating epithelium at the base of the crevice will usually be included in the ulceration. Whether ulceration is primary or secondary in sequence, the tendency is for the process to become reduced to a chronic non-ulcerative inflammation, with the epithelium covering the separated soft tissue.

We have stated that the diagnosis of a cemental-gingival pocket is extremely difficult in its early stages. While this lesion may occasionally have an acute onset, evidenced by redness, swelling and tenderness to touch, this stage as a rule soon passes into the sub-acute stage. In the absence of the microscope, we have only the probe as a diagnostic aid. Regardless of whether there is a visible pus formation or not, a separation of soft tissue from the tooth which permits the insertion of a probe to a depth of more than two millimeters is, in the average case, indicative of pocket formation.

The distance from the amelo-cemental junction to the level of the alveolar crest, or in other words, the depth of the cemental gingiva, is on the average, two millimeters. The average depth of the gingival crevice on all surfaces is also two millimeters. It therefore follows that when the probe can be inserted under the gingival margin for a dis-

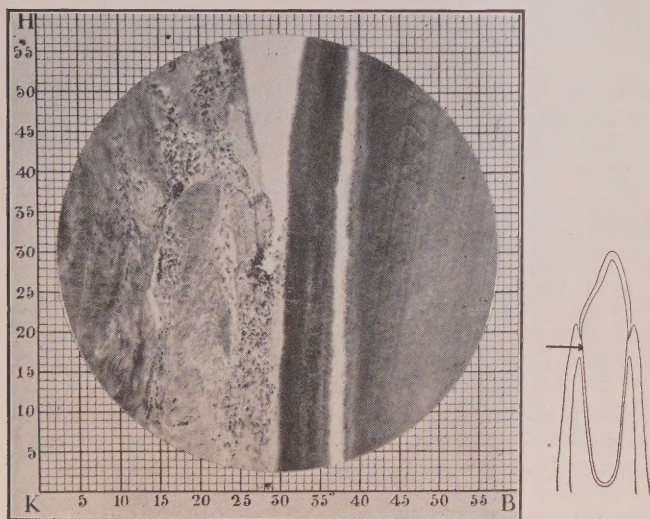


Fig. 88—x 187. Pocket formation through the extension of ulceration along the cemental surface. (This is a later stage of chronic ulcerative cemental gingivitis.)

H K 28 x K B 28, Base of ulcer.
H K 28 x K B 34, Cementum.

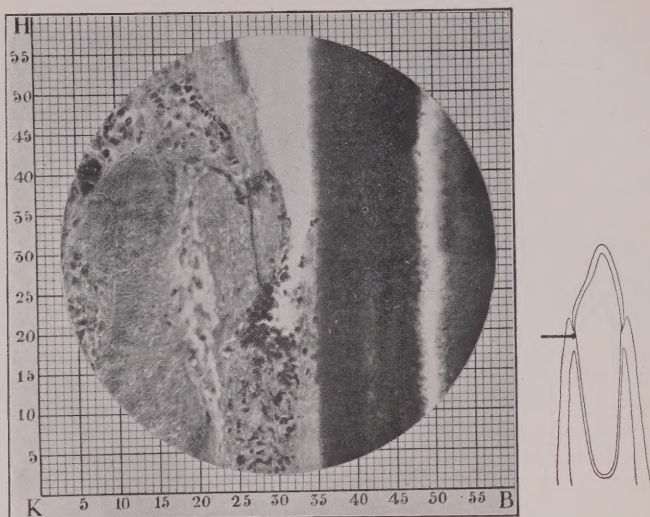


Fig. 89—x 375. Higher magnification of the specimen shown in the preceding illustration.

H K 21 x K B 30, Base of ulcer.

H K 51 x K B 27, Extremity of cervicular epithelium.

H K 7 x K B 29, Leukocytic infiltration. Note that pericemental tissue still persists above the deepest extension of the ulcerative process.

tance between two and four millimeters it indicates pocket formation of corresponding depth in the cemental gingiva. If it penetrates more than four millimeters, it may be assumed that the pocket involves the pericementum.

PHASE 2. CHRONIC PERICEMENTITIS.

✓ Pericemental Pocket

A pericemental pocket is an extension of a cemental-gingival pocket into the pericementum. It will be recalled that the pericementum is that tissue which fills the space between the root of the tooth and the wall of the alveolus.

The pericementum is subject to circulatory disturbances due to interference with its normal function. It thus may become subject to infection which may extend into it from the cemental gingiva. Previous to infection of the pericementum by extension from the cemental gingiva either with or without pocket formation, the crest and associated alveolar process has become resorbed through the Rarefying Pericementitis Fibrosa, already described. The teaching of Black is that bone absorption occurs secondarily to the detachment of the fibres which had been originally inserted into it, and that

"detachment of the peridental membrane from the cementum is the principal factor in causing loss of the bone."¹ If bone absorption occurred in this sequence, it would necessitate the extension of the pocket between the tooth and the adjacent alveolar wall.

While bone absorption frequently takes place in such a way as to leave a considerable amount of bone above the base of the pocket, the significant fact is that the bone which constituted the original alveolar wall of the affected tooth is invariably resorbed in advance of the extending pocket. Furthermore, the bone which remains above the level of the base of the pocket, when viewed under the microscope, is seen to be so far removed from the affected tooth as to be well beyond the confines of the region in which the pocket was originally formed.

Examination of over six hundred specimens of pocket formation in its relationship to bone absorption has failed to reveal a single instance in which the pocket extends between the root of the tooth and the original alveolar wall.

The process by which a pocket is formed in the pericementum is identical with that which previously led to pocket formation in the cemental gingiva.

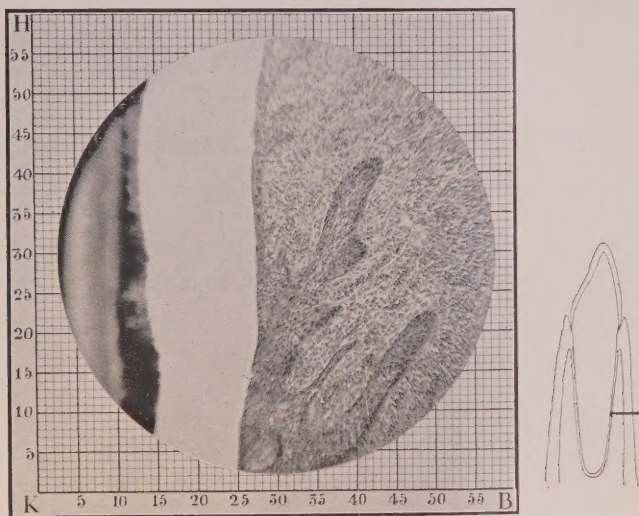


Fig. 90— x 125. Extension of the pocket into the pericementum.

- H K 25 x K B 22, Pocket.
- H K 20 x K B 30, Epithelial covering of detached soft tissues.
- H K 15 x K B 13, Deposit of calculus in pocket.
- H K 20 x K B 7, Cementum.
- H K 25 x K B 44, Leukocytic infiltration. Note entire absence of alveolar bone in this section.

¹Special Dental Pathology; G. V. Black, p. 170.

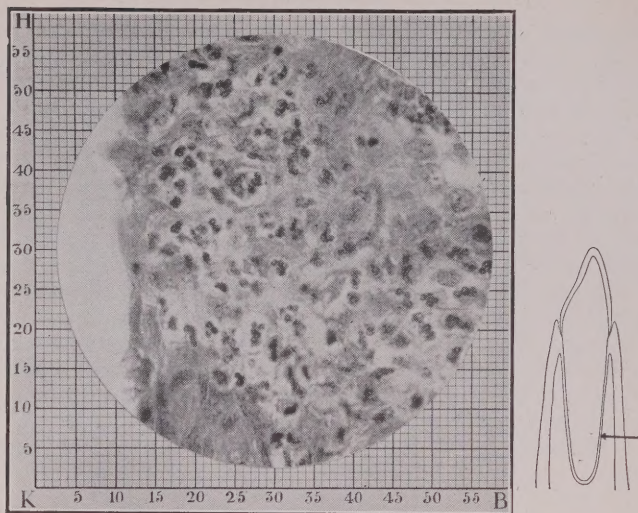


Fig. 91—x 1125. Very high magnification of the surface of the detached soft tissue shown in the preceding illustration. Note the intact epithelium on the surface, and the presence of polymorphonuclear leukocytes. The indications are that an inflammatory exudate of a purulent character is passing through the epithelial covering into the pocket. As yet there is no actual ulceration.

- | | |
|------------------|-------------------------------------|
| H K 30 x K B 6, | Pocket. |
| H K 33 x K B 13, | Epithelial covering of soft tissue. |
| H K 40 x K B 15 | } Polymorphonuclear leukocytes. |
| H K 33 x K B 30 | |
| H K 19 x K B 27 | |

Due to the progression of the inflammation, there is an active proliferation of the epithelium apically along the cementum. As in the case of cemental-gingival pocket formation, the pathologic process may exhibit either separation of the proliferating epithelium from the cementum, or an ulceration at the base of the advancing pocket. In either case, the significant fact is the constant tendency, and one which is successfully carried out in the majority of cases, for this epithelium to cover the separated connective tissue (figs. 90, 91, and 92). When a large number of specimens are examined it is surprising how little ulcerated tissue is to be found even in the deepest pockets, or in contact with large masses of calculus.

While pocket formation can and does take place through the stripping of the fibres of the pericementum by the extension of the process of ulceration, examination of hundreds of specimens showing pocket formation has forced the author to broaden his concept of the nature of this pathologic process. The cumulative evidence on this point emphasizes more and more the importance of the role played by

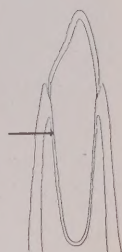
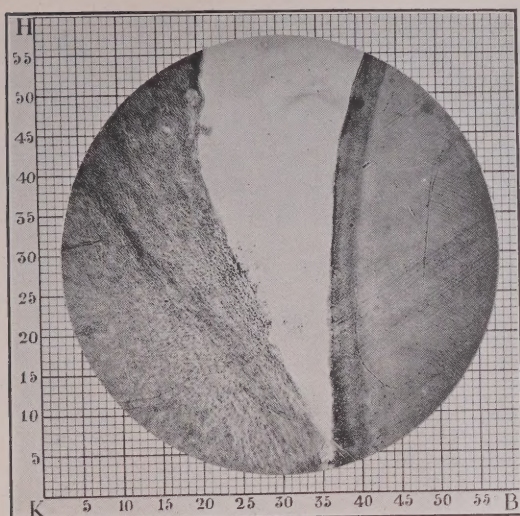


Fig. 92— x 94. Pericemental pocket. Extensive ulceration of the soft tissues of the cemental gingiva and pericementum.

The ulcerated surface extends from H K 51 x K B 21 (which was the point of original attachment of the crevicular epithelium) to the present base of the pocket.

epithelial proliferation in pocket formation. This evidence also tends to minimize the part played by ulceration as the important factor in the extension of the pocket. It thus becomes plain that our theories regarding treatment should be based on the assumption that in practically all pockets, the detached tissue sooner or later becomes covered with epithelium. In other words, there is a constant tendency, due to the defensive power of the organism, to reduce this disease process to a chronic non-ulcerative type of inflammation. It should also be noted that ulceration is not a prerequisite to a suppurative pericementitis, as the inflammatory exudate may pass from the tissues through the epithelium into the pocket. At times, due either to an increased virulence of the bacteria or a decreased local or general resistance, there may be exacerbations of acute inflammation, with increased purulent exudation, and other local manifestations (figs. 93, 94 and 95). At such times the inflammatory process may terminate in actual ulceration, which may persist for a considerable period of time. Due to inadequate drainage or other factors, acute abscesses may develop near the base of the pocket. These have been known clinically as pericemental abscesses.

The cementum underlying the pocket and from which the soft tissues have been detached always presents a septic surface. This is due to the frequent occurrence of serum deposits, to the retained

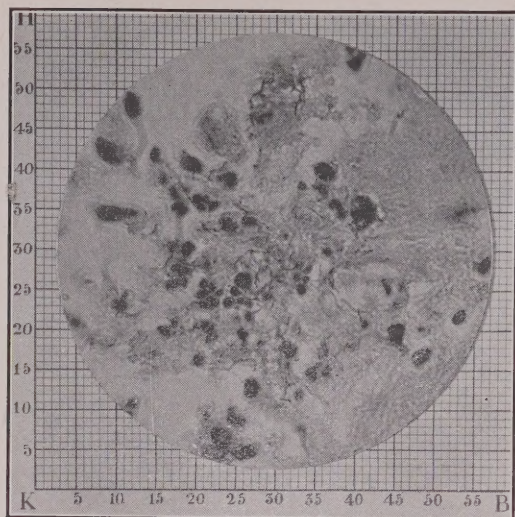


Fig. 93— x 1500. Chronic Pericementitis (Pocket in Pericementum). Bacteria in an ulcer at the border of a pericemental pocket.

H K 24 x K B 22

H K x 26 x K B 33

H K 21 x K B 53

H K 27 x K B 28

} Pus-cells (Dead polymorphonuclear leukocytes).

} Lymphocyte.

In this region occur numerous bacilli.

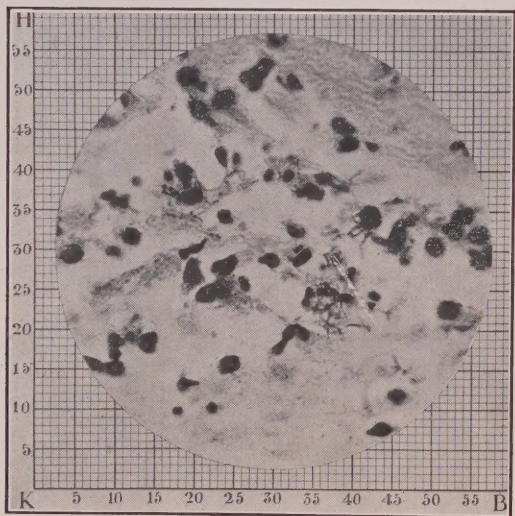


Fig. 94— x 1500. Chronic Pericementitis (Pocket in Pericementum). Bacteria in an ulcer at the border of a pericemental pocket.

H K 32 x K B 23

H K 20 x K B 37

} Diplococci.

} Bacilli.

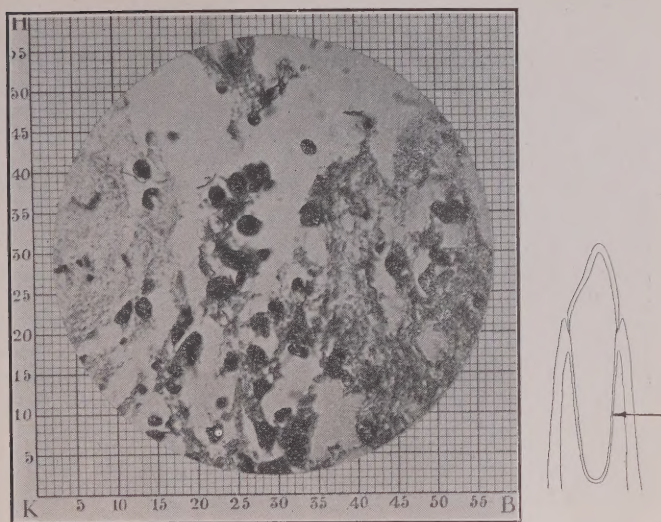


Fig. 95— x 1500. Chronic Pericementitis (Pocket in Pericementum). Bacteria in an ulcer at the border of a pericemental pocket.

H K 39 x K B 22, Bacilli.

Note occurrence of bacilli and cocci throughout the field.

ends of the principal fibres in the insertion layer, and occasionally to small remnants of necrotic pericementum adhering to the cemental surface. There is no microscopic evidence to show that in the average case the cementum is penetrated deeply by bacteria. That such penetration may take place is, however, shown by the accompanying photomicrographs (figs. 96 and 97).

We see no reason from the biological standpoint to agree with Black's statements regarding the impossibility of securing reattachment of the overlying soft tissues to denuded cementum. Black has laid down a postulate which may be summed up in the following sentence. "The key to the treatment of suppurative pericementitis is in the statement that suppurative detachments of the periodontal membrane are permanent detachments."² On the contrary, clinical evidence has been accumulating for years to support the contention that reattachment is possible. We are now in a position to bring forth histological evidence which supports the claims of prominent clinicians and controverts the doctrine advanced by Black. The accompanying photomicrographs were taken from sections of a tooth treated by McCall. The case was shown as a clinic on reattachment at a meeting of the Alumni Association of the University of Buffalo in 1912. The claims of reattachment made to those who

²Special Dental Pathology, G. V. Black, p. 185.

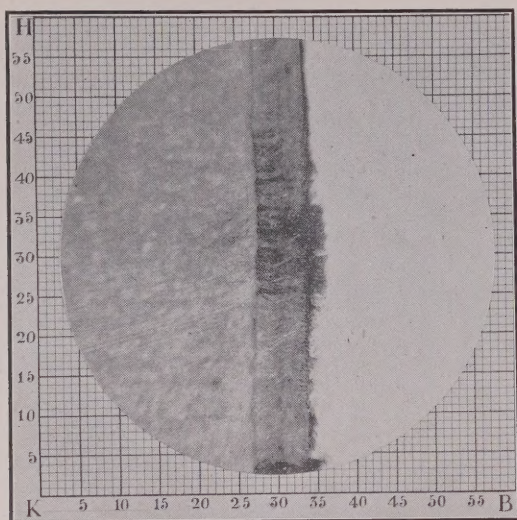


Fig. 96—x 250. Penetration of cementum by bacteria. This condition is comparatively rare.

H K 15 x K B 31, Normal cementum.

H K 30 x K B 32, Cementum penetrated by bacteria.

H K 33 x K B 35, Bacteria on surface of cementum.

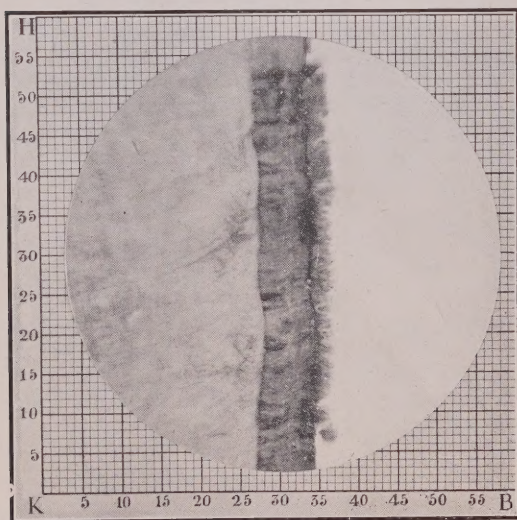


Fig. 97—x 250. Penetration of cementum by bacteria. Note that early penetration of the dentinal tubules by bacteria is shown.

H K 37 x K B 36, Bacteria on surface of cementum.

H K 44 x K B 28, Deep penetration of cementum by bacteria.

H K 33 x K B 25, Penetration of dentinal tubules by bacteria.

inspected the case were not questioned. This tooth and surrounding tissue was surgically removed in 1920. These sections show a reattachment of the connective tissue to the cementum surface. In addition, there is to be observed the phenomenon of a tenacious adherence of the crevicular epithelium to the the cementum. It will be noted that the connective-tissue fibres run parallel with the curetted cemental surface; also that the principal fibres, cementoblasts and epithelial cords typical of the normal are absent (figs. 98, 99, 100 and 101).

Not only has it been found that reattachment of the surrounding soft tissue to the cementum may be induced, but evidence is not lacking that regeneration of alveolar bone may take place. The supposed hopelessness of the building up of bone can readily be demonstrated to be without foundation, in fact, on the contrary many periodontists have offered radiographs which furnish indubitable proof of bone regeneration. The accompanying radiographs (figs. 102 and 103) are taken from the author's files. It will be noted in this case that the radiographs give evidence of a complete restoration of the alveolar crest, a type of bone regeneration usually regarded as least likely to be accomplished.

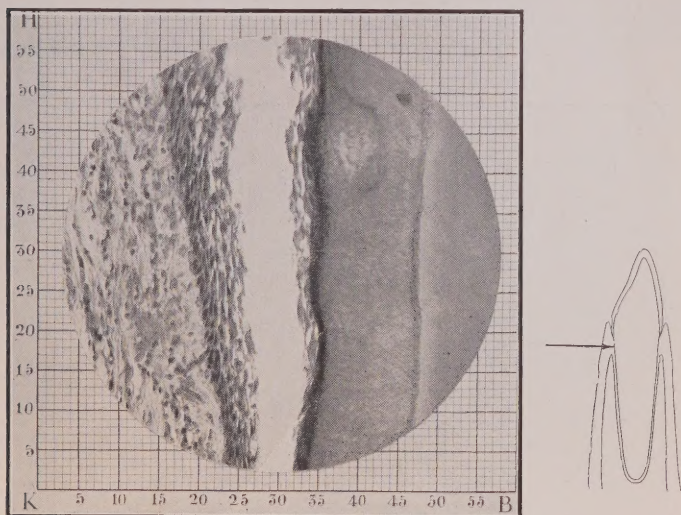


Fig. 98—x 375. Reattachment. This photomicrograph is taken near the top of the former pocket, and shows the tenacity of the adherence of the epithelium to the once denuded cementum. Note the wavy outline of the curetted cemental surface.

H K 35 x K B 35, Curetted cemental surface.

H K 35 x K B 32, Adherent epithelium.

H K 35 x K B 29, Space produced by tearing of epithelium.

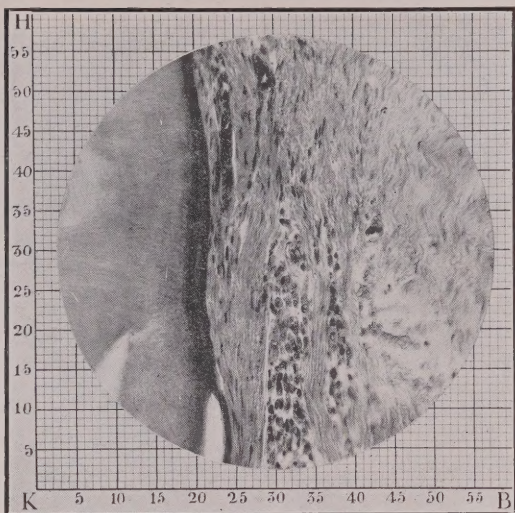


Fig. 99—x 375. Reattachment. This photomicrograph shows reattachment of the connective tissue farther down in the former pocket. Note that the connective-tissue fibres lie parallel with the cemental surface. Note also absence of principal fibres, cementoblasts and epithelial cords.

H K 35 x K B 22, Cemental surface.

H K 18 x K B 27, Connective-tissue fibres.

H K 44 x K B 24, Blood-vessel.

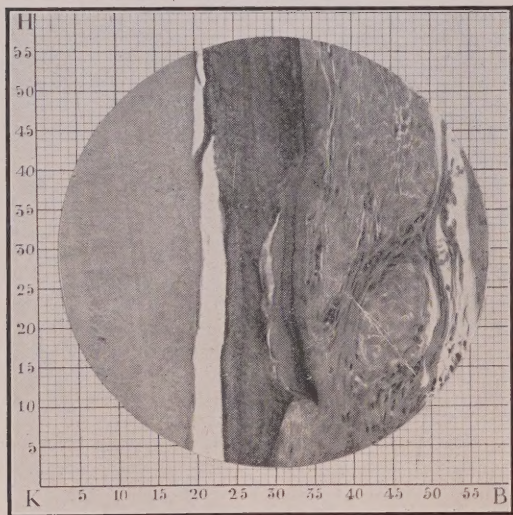


Fig. 100. Reattachment. New cementum laid down over the curetted cemental surface. While certain areas show this condition, yet the chief feature of the process is the reattachment of connective tissue to the original curetted surface.

H K 49 x K B 35 }

H K 25 x K B 33 } Secondary cementum laid down over curetted cementum.

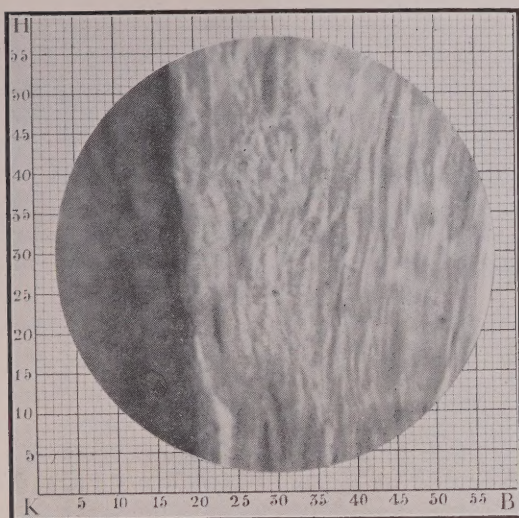


Fig. 101— x 2250. Reattachment. This photomicrograph shows the connective-tissue cells and fibres lying parallel to the cemental surface.

H K 52 x K B 29 }
 H K 30 x K B 33 } Connective-tissue cells.
 H K 5 x K B 28 }

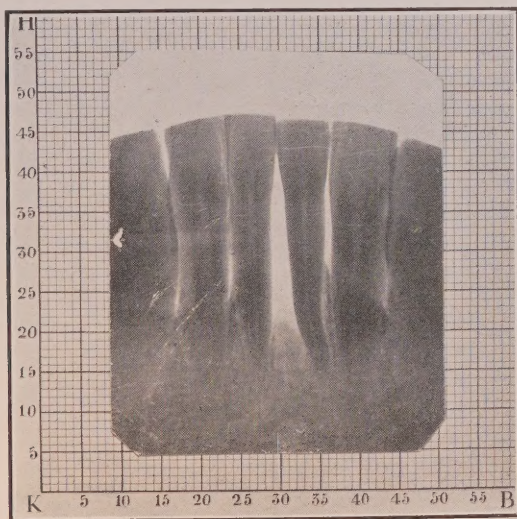


Fig. 102—Regeneration of Alveolar Bone. Radiograph taken Mar. 1, 1921. Note that marked rarefaction of bone has occurred in the septal bone between lower central (median line). Age 43.

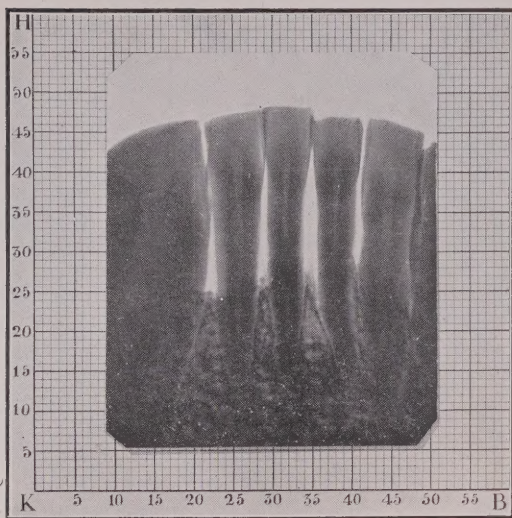


Fig. 103—Regeneration of Alveolar Bone. Radiograph taken Mar. 1, 1922, at approximately the same angle as the preceding radiograph. Note the height of the restored alveolar crest as compared with the height of the alveolar crests between the adjoining teeth. Note formation of an apparently normal lamina dura.

In view of the evidence just submitted, it is interesting to refer to the pessimism of most writers on this subject, regarding the possibility of cure in a mature case of Chronic Periodontitis, Complex. That this pessimistic attitude has not been justified may be demonstrated through a review of the following fundamental postulates whose truth we believe has been established in this paper.

1. The progressive nature of both of the basic lesions (Rarefying Pericementitis Fibrosa and Infective Periodontitis). It will be recalled that the regressive changes in the alveolar bone are secondary to progressive changes in the pericementum.
2. The demonstration that reattachment of the soft tissues to the cementum may be induced.
3. The demonstration that rarefaction of the alveolar bone can be arrested, and that, in many cases, an actual regeneration of the alveolar bone may be induced.

These three postulates may be summed up in the form of the following proven hypothesis,—*Chronic Periodontitis belongs in the category of curable diseases.*

Deposits of calculus are not, as a rule, found extending to the depth of the pocket. Almost invariably, in pocket formation, the soft tissues are detached from the cemental surface for a considerable distance in advance of the deposition of calculus. Serous calculus is, therefore, not a primary agent in pocket extension. Its precipitation occurs subsequent to the separation of the soft tissues from the cementum. These concretions act as mechanical injurious agents, and also as a source of chemical irritation, e.g., toxins derived from contained bacteria. They thus are to be looked upon as sustaining factors in the maintenance of inflammation of the overlying soft tissue (figs. 104 and 105).

The type of exudation from periodontal pockets is commonly known as pus, and is made up of leukocytes in abundance, serum in varying quantities, fibrin usually of scant amount, and living and dead bacteria. Of the leukocytes, the polymorphonuclear predominate although endothelial leukocytes and lymphocytes may be fairly abundant.

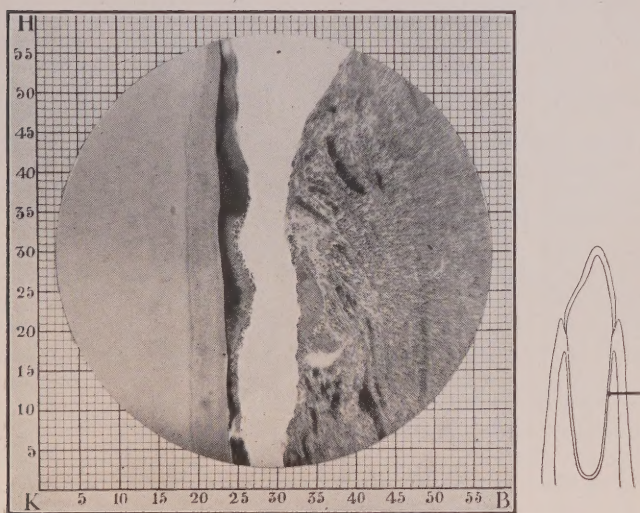


Fig. 104— x 125. Calculus on cemental surface in pocket.

H K 30 x K B 21, Cementum.

H K 38 x K B 25, Calculus.

H K 30 x K B 30, Pocket.

H K 30 x K B 40, Soft tissue.

H K 40 x K B 39, Engorged blood-vessel.

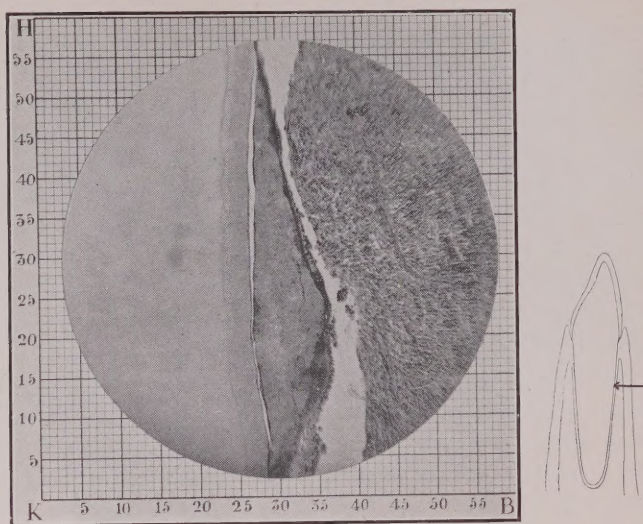


Fig. 105— x 125. Calculus on cemental surface in pocket.

H K 25 x K B 32, Calculus.

H K 25 x K B 45, Soft tissue.

Note that entire surface of soft tissue is covered with epithelium.

PHASE 3. ✓ INFECTIVE OSTEITIS (RAREFYING).

It has been stated that alveolar resorption has taken place, without infection and in advance of the extension of the pocket. The deepening pocket on account of its sheltered location and its contained débris, serves as an incubator which is particularly favorable to the growth of micro-organisms. Through increased absorption of toxins, and actual infection, the phenomena of infective osteitis are added to those of non-infective rarefaction of the alveolar bone. In other words, the inflammatory process brought about by infection extends to the alveolar bone, and through its contributing factors, e.g., acids produced by bacterial action on the fluids of the environment, products arising from cell destruction, and secretory products of abnormal tissue-cells, further absorption takes place.

In the fibrillar connective tissue which has been formed subsequent to the non-infective absorption of bone, there is to be noted an extensive small-cell infiltration, which also, in certain areas, has entered the marrow-spaces. The activity produced by chronic inflammation in the soft tissues in the marrow-spaces or Haversian canals results in certain striking changes in the dense basement-substance of the bone. As a result of these changes, either the calcified ground-substance is absorbed and replaced by young cellular forms of fibrillar

connective tissue or the marrow-spaces undergo progressive reduction in size by new-formed lamellae on their walls. These alterations are named, respectively, rarefying and condensing osteitis, which terms simply indicate the local results of inflammation.

The rarefaction of the bone in infective rarefying osteitis occurs by enlargement of the medullary spaces and Haversian canals, with consequent disappearance of the spongy bone substance. The soft structures of the bone become very cellular and vascular and are converted into granulation tissue. Throughout this tissue, there is a marked infiltration of lymphocytes and plasma cells. Under the influence of this tissue the ground-substance of the bone becomes absorbed. (Figs. 106, 107, 108, 109, 110 and 111.)

A prominent feature of the histological picture is the marked disturbance of pericemental circulation. The blood-vessels are greatly dilated, and, in many instances, the red blood-cells have escaped into the surrounding tissues. Such hemorrhages are usually small, but their occurrence, on the other hand, may be wide-spread throughout the pericementum. (Fig. 112.)

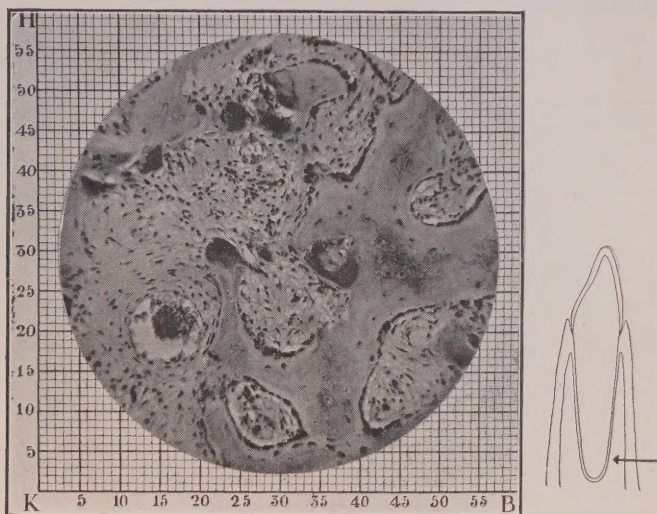


Fig. 106. Infective Osteitis (Rarefying). This photomicrograph shows trabeculae of alveolar bone undergoing absorption. Note the leukocytic infiltration of the soft tissue in the medullary spaces.

H K 20 x K B 25, Trabecula of alveolar bone.

H K 30 x K B 22, Osteoclast absorbing alveolar bone.

H K 17 x K B 29, Alveolar bony trabecula undergoing absorption.

H K 39 x K B 27, Leukocytic infiltration.

H K 21 x K B 17, Engorged blood-vessel.

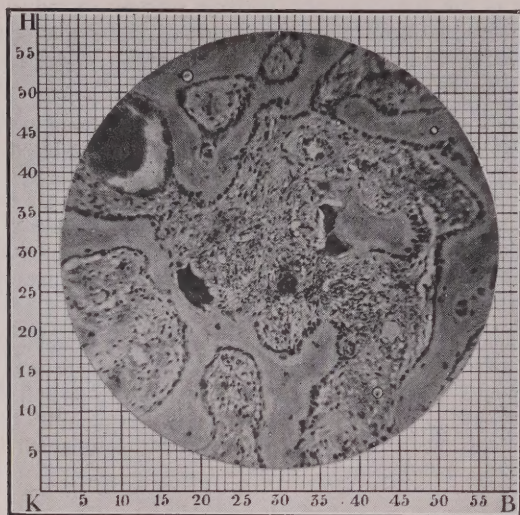


Fig. 107. Infective Osteitis (Rarefying).

H K 26 x K B 20, Osteoclast. H K 26 x K B 36, Leukocytic infiltration.
H K 34 x K B 41, Remnant of bony trabecula.

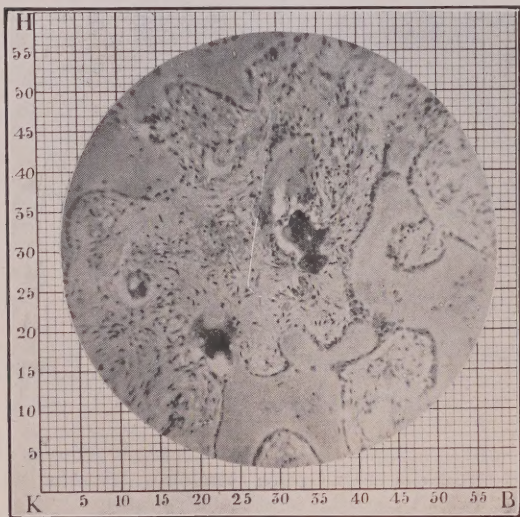


Fig. 108. Infective Osteitis (Rarefying).

H K 19 x K B 22 } Osteoclasts.
H K 31 x K B 34 }
H K 22 x K B 40, Osteoblasts. Note the continuous line of osteoblasts on
the surface of the bony trabeculae.
H K 40 x K B 37, Leukocytic infiltration.

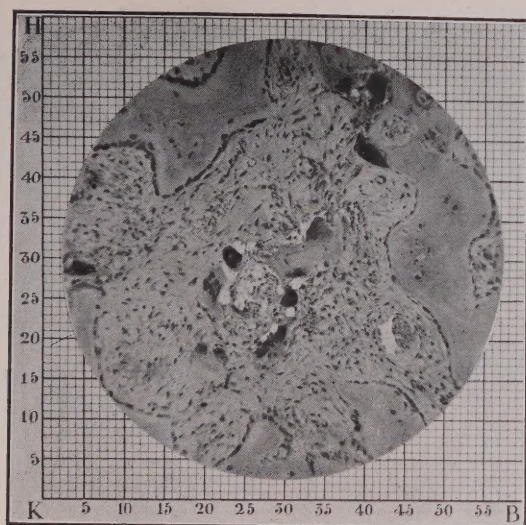


Fig. 109. Infective Osteitis (Rarefying).

H K 31 x K B 23 Osteoclasts.

H K 44 x K B 40

H K 31 x K B 33, Remnant of bony trabecula.

H K 27 x K B 28, Leukocytic infiltration.

H K 21 x K B 45, Engorged blood-vessel.

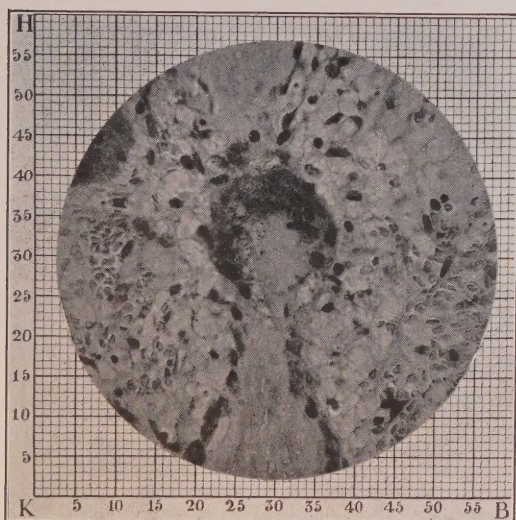


Fig. 110—x 750. High magnification of an osteoclast at the extremity of a bony trabecula.

H K 30 x K B 30, Extremity of bony trabecula.

H K 38 x K B 30, Crescentic osteoclast.

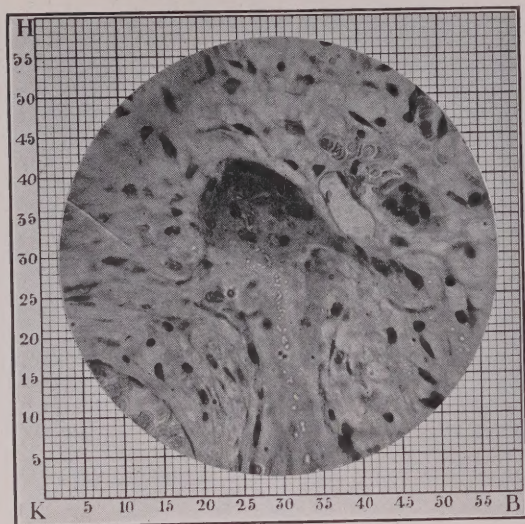


Fig. 111— x 750. High magnification of an osteoclast.

H K 28 x K B 30, Extremity of bony trabecula.

H K 31 x K B 27, Cytoplasm of osteoclast.

H K 40 x K B 27, Multiple nuclei of osteoclast.

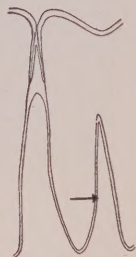
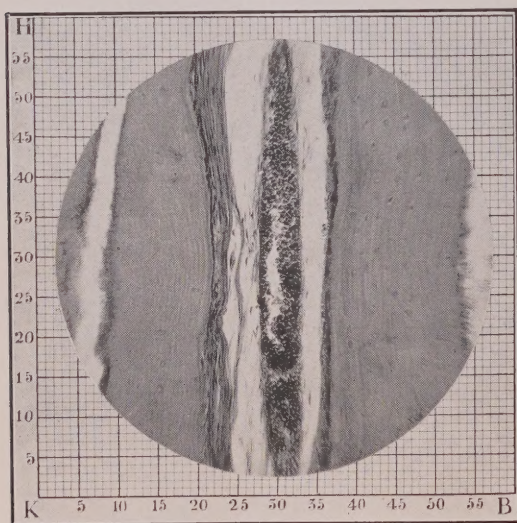


Fig. 112— x 250. Dilatation of a blood-vessel in the pericementum in Infective Osteitis.

H K 30 x K B 31, Blood-vessel.

H K 30 x K B 22, Border of cementum.

H K 30 x K B 36, Border of alveolar process.

In condensing osteitis, through increased osteoblastic activity, the lamellae undergo progressive thickening and the marrow-spaces and Haversian canals are correspondingly reduced. In the alveolar process, this condition is frequently noted about teeth in over-function. Here it may be looked upon as a compensatory effort on the part of the bone to maintain a state of mechanical equilibrium. The toxins of bacteria of low virulence, by their mild irritation, are also regarded as causative factors in the production of condensing osteitis. (Figs 113 and 114.)

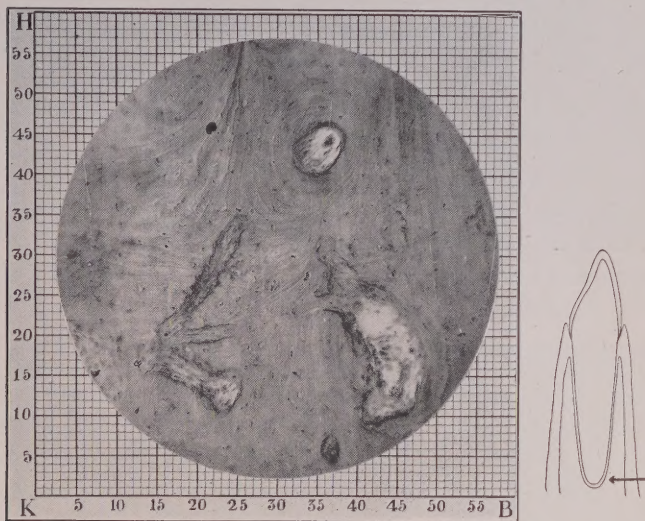


Fig. 113— x 187. Condensing Osteitis.

H K 28 x K B 22 } Medullary spaces obliterated by new bone formation.
 H K 20 x K B 21 }
 H K 26 x K B 39, Medullary space in process of obliteration.

A modification of Chronic Periodontitis, Complex may occur when this disease condition involves the tissues in the bifurcation of the roots of any multi-rooted tooth.

The lesions occur in the following order:

1. Rarefying Pericementitis Fibrosa, as described previously.
2. Chronic Gingivitis (cemental-gingival pocket).
3. Chronic Pericementitis (pericemental pocket).
4. Formation of granuloma in the bifurcation. The soft tissue remaining in the bifurcation after the alveolar rarefaction, is converted into a granuloma by the invasion of bacteria from the pocket (figs. 115, 116, 117, 118).
5. Infective Osteitis (Rarefying).

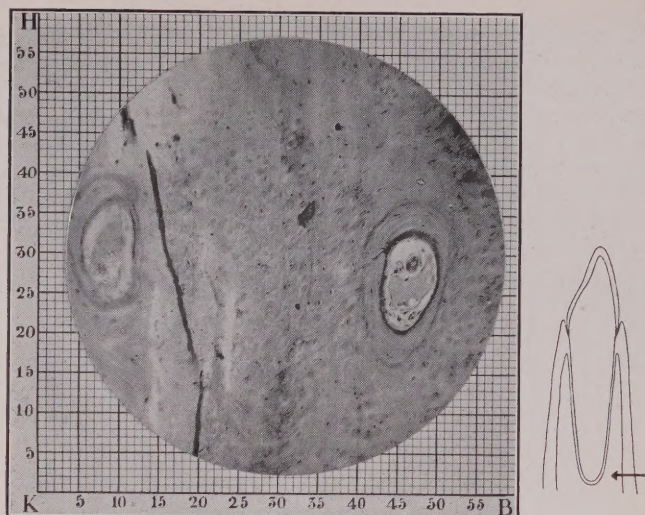


Fig. 114—x 187. Condensing Osteitis.

H K 38 x K B 8 } New lamellae of bone being laid down around medullary spaces.
H K 35 x K B 46 }

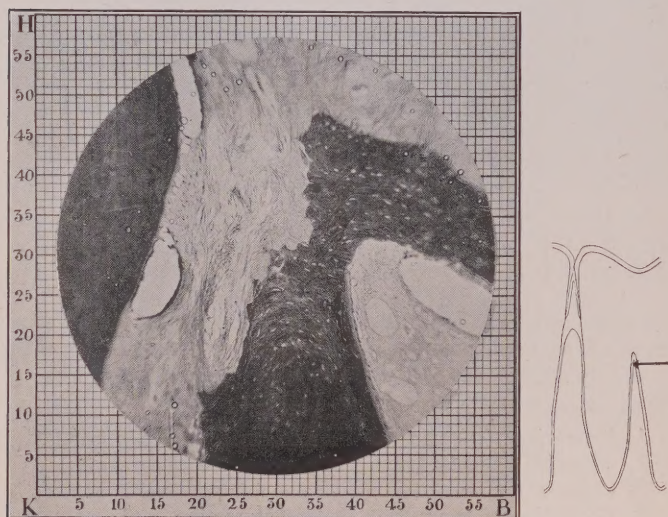


Fig. 115—x 94. Rarefying Pericementitis Fibrosa. Rarefaction of the alveolar crest in the bifurcation of a lower molar.

H K 33 x K B 34, Excavations in the border of alveolar bone.
H K 35 x K B 27, Pericementum.
H K 40 x K B 15, Cementum.
H K 30 x K B 42, Absorption in the body of the alveolar bone.

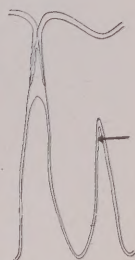
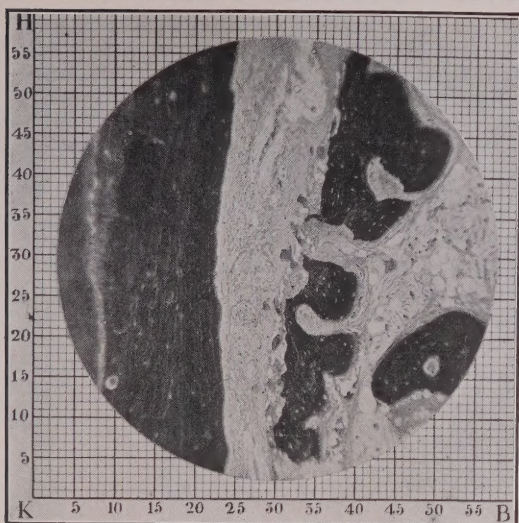


Fig. 116— x 94. Rarefying Pericementitis fibrosa. Rarefaction of the alveolar process in the same specimen as shown in the preceding illustration. The alveolar bone is undergoing segmentation.

H K 25 x K B 28, Pericementum.
 H K 25 x K B 23, Border of cementum.
 H K 40 x K B 40 Segments of alveolar bone.
 H K 16 x K B 46

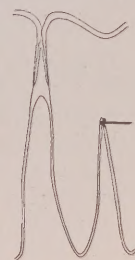
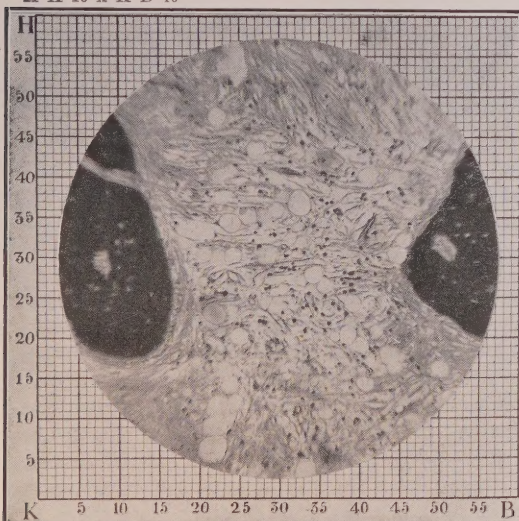


Fig. 117— x 125. Leukocytic innitration in the connective tissue which has replaced the alveolar bone in the bifurcation. Beginning of granuloma formation.

H K 28 x K B 39, Leukocytic infiltration.
 H K 28 x K B 13 }
 H K 25 x K B 53 } Remnants of alveolar bone.

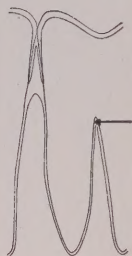
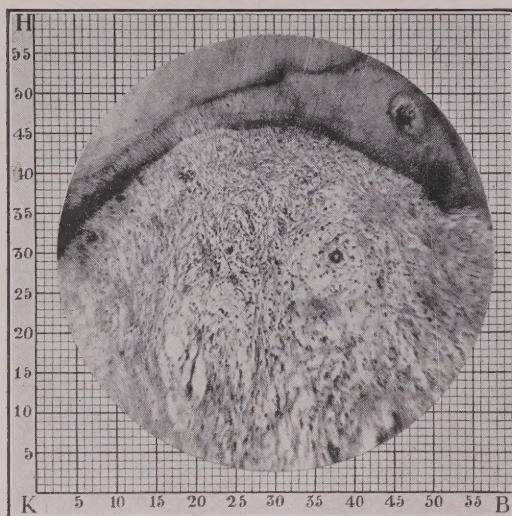


Fig. 118— x 125. Granuloma in bifurcation.

H K 50 x K B 23, Dentinal-cemental junction.

PART V:

HISTO-PATHOLOGY OF THE PERIAPICAL TISSUES.

Periapical diseases contiguous to the cementum, and with which the practitioner comes into contact daily, may be divided into three main classes:

- (1) Granulomata
- (2) Abscesses
- (3) Dental Cysts.

In general, a granuloma represents a reaction to a mildly injurious agent, exemplified in the periapical tissues by bacteria low in virulence, chemicals in low concentration used in root canal treatment, and mechanical agents not severe in character. The actual injury by these types of injurious agents is slight, as a rule, and seldom can be shown morphologically. On the other hand, the inflammatory reaction is usually marked and frequently leads to serious consequences. This reaction, as demonstrated in the dental granuloma, always takes place at the site of injury, the usual location being the apex of a tooth. However accidental perforation of the bifurcation of a multi-rooted tooth, or through the cementum on the side of the tooth, quite often leads to the production of this lesion in these areas.

1. GRANULOMATA.

A granuloma consists, as the name implies, chiefly of granulation tissue. At the expense of the resorption of the alveolar lamina dura, the granuloma increases in size, and finger-like extensions project into the medullary spaces of the bone. During the essayist's work on the subject, Thoma's classification was studied, and will be used in the following.

(a) Simple.

This type of granulomata consists chiefly of a proliferation of vascular endothelium and fibroblasts. The site of the injury becomes infiltrated with lymphocytes and, in smaller numbers, polymorphonuclear leukocytes. Endothelial cells are frequently seen in large numbers, owing to the presence of certain foreign substances. A conspicuous feature of nearly all granulomata is the presence of many plasma cells, easily differentiated from the lymphocytes by their eccentric nuclei, often two to four in number. They also differ from the lymphocytes in the "large increase in the amount of cytoplasm, which has marked basophilic properties, except for a small acidophilic area adjoining the nucleus, in which the centrosomes are always found." (Mallory.)

The function of the lymphocytes is believed to be the neutralization and disposal of injurious substances absorbed through the lymphatics. With increase in size of the granuloma and absorption of the lamina dura, its outer portion is characterized by the arrangement in bundles of connective-tissue fibres, which lie, as a rule, in a direction parallel with its outer surface. This has been termed the capsule. Extensions of the capsule project into the medullary spaces of the bone. Examination of a number of sections very often reveals the presence of small areas of osseous tissue, which has become isolated from the alveolar process. The capsule is highly vascularized, numerous fairly large blood-vessels maintaining communication between the inner parts of the granuloma and the surrounding bone (figs. 119, 120 and 121).

Beneath the capsule, there may be distinguished a much thicker layer of less dense reticular connective tissue, containing a great number of lymphocytes and plasma cells, and some polymorphonuclear leukocytes.

(b) Epitheliated.

When the pericementum contains the epithelial cords described previously, "the masses epitheliaux of Malassez," and upon involvement of these cells in the inflammatory process, a striking feature of the microscopic picture is their proliferation through the tissue, in the form of plugs, strings or trellis-work. Winding and branching cords often constitute a net-work of epithelial cells through the lesion. This type is known as an epitheliated granuloma. (fig 122).

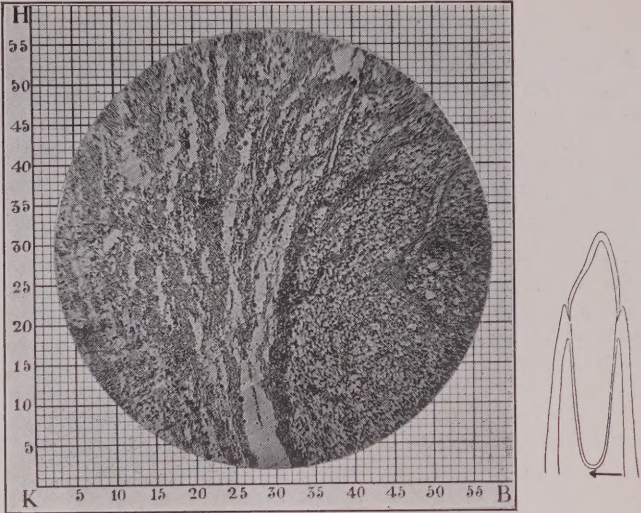


Fig. 119— x 94. Simple granuloma, showing connective-tissue capsule.
H K 25 x K B 32, Connective-tissue capsule.
H K 20 x K B 43, Granulation tissue.

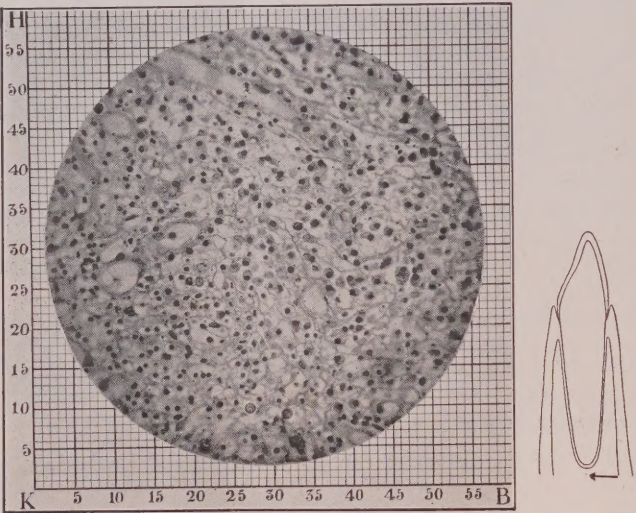


Fig. 120— x 375. Simple granuloma.
H K 50 x K B 29, Proliferating endothelial cells forming a new blood-vessel.
H K 39 x K B 26 } Plasma cells.
H K 27 x K B 37 }
H K 27 x K B 27 }

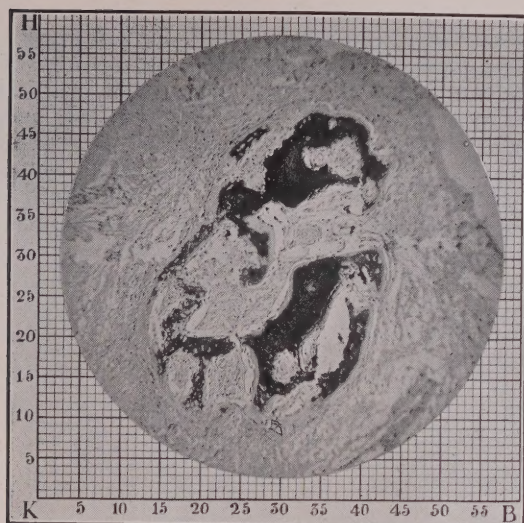


Fig. 121— x 94. Remnant of alveolar bone surrounded by granulation tissue and undergoing absorption.

H K 40 x K B 31 }
H K 23 x K B 33 } Large segments of alveolar bone.

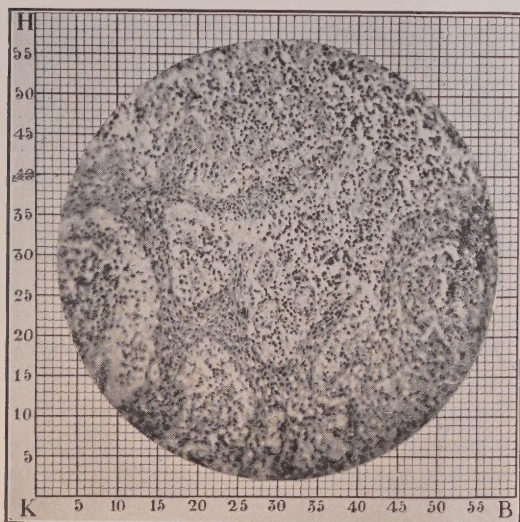


Fig. 122— x 188. Epitheliated granuloma.

H K 30 x K B 15 }
H K 21 x K B 35 } Proliferating epithelium.
H K 35 x K B 48 }

(c) *Granuloma showing Necrosis.*

Here and there throughout certain granulomata, areas may be noted where a number of cells are separated from the others and have undergone degeneration. Usually in this type there is an increase in the number of polymorphonuclear leukocytes. The essayist regards this lesion as a potential abscess. When the destructive process becomes extensive and suppuration results, if the connective-tissue capsule is not broken down, the condition is known as blind abscess. In certain cases, however, a sinus to the gum is produced.

(d) *Dental Granulomata showing Retrograde Processes.*

Evidence of cholestrin formation is seen in many sections of granulomata. Cholestrin crystals can be recognized by the acicular spaces left by the crystals during dehydration in alcohol (fig. 123).

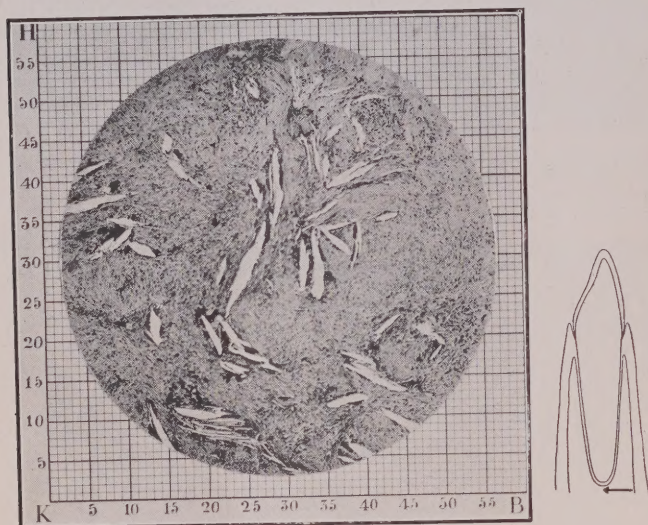


Fig. 123— x 94. Granuloma showing cholestrin formation.

H K 30 x K B 25 } Spaces in the section formerly occupied by cholestrin
H K 30 x K B 34 } crystals.

(e) *Dental Granulomata showing Cyst Formation.*

In epitheliated granulomata, showing, in certain areas, evidence of degenerative processes, the epithelial cords, previously described, manifest a definite tendency to surround and encapsulate such foci. This can be looked upon as the beginning of root-cyst formation. True simple granulomata contain no epithelial cell clusters, and for this reason can never develop into these root-cysts. Dewey, in speaking of beginning cyst formation, has stated: "Strands grow out from

this epithelial layer into the granulation tissue and encircle and snare off other regions, which, being cut off from the surrounding tissues, are poorly nourished, and hence the tissue undergoes degenerative processes. When these are complete, the epithelial barrier is also dissolved and the detritus added to the cystic content" (fig. 124).

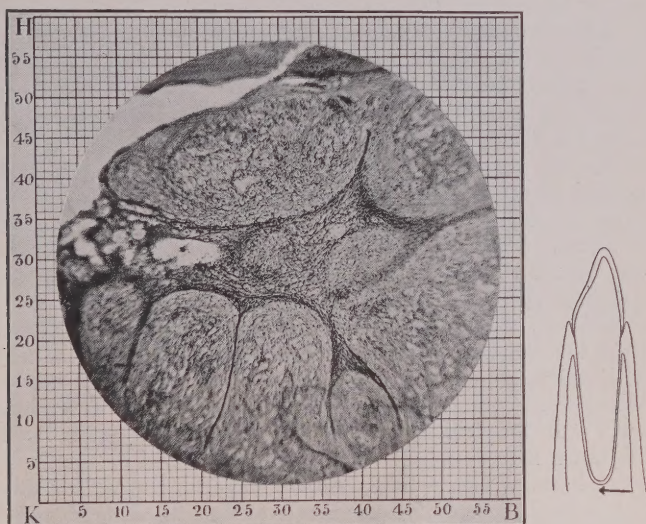


Fig. 124— x 9. Cystic granuloma.

H K 55 x K B 27,	Apical cementum.
H K 20 x K B 12	} Proliferating epithelial strands tending to encircle
H K 15 x K B 23	
H K 18 x K B 39	

On the same question, Prieswerk has written the following: "The epithelial cells generally lie close together, but in some areas they are interrupted by minute lacunae, which are filled with granular fragments of degenerated cells. Such lacunae may be considered primitive cysts, for they develop later into large cystic cavities, lined with epithelium."

2. ABSCESSES.

I. Acute

- | | | |
|-------------|---|---------------------------------------|
| II. Chronic | { | (a) Blind. |
| | | (b) With a Sinus. |
| | | (c) Discharging through a root canal. |

I. Acute Abscesses.

I. An acute alveolar abscess may be regarded as a reaction to strong injurious agents and the injury produced by them. In the

periapical tissues, this is usually brought about by the invasion of a large number of pyogenic bacteria into these tissues from the root canal.

An initial temporary constriction of the arteries is followed by a dilatation of the vessels with a more rapid flow in the blood stream. Then the blood flow becomes slower, although the dilatation continues. The veins also show an increase in their calibre with increased flow of blood followed by a slowing in the rate of the flow. In some of the capillaries and veins, flow of blood may entirely cease.

Following a margination of leukocytes along the vessel-walls, into the spaces between the principal fibres of the pericementum which pass from the cementum to the alveolar wall, there takes place an emigration of these leukocytes, which by altering their contours and piercing the vessel-walls pass out into the lymph-spaces of the periapical tissues. The polymorphonuclear leukocytes play the most important part in this type of inflammatory reaction and are the first to pass through the walls of the vessels into the surrounding tissues. In the capillaries, red blood-cells as well as the leukocytes pass through between the endothelial cells, but their movement, unlike the leukocytes, is entirely a passive one.

Some of the constituents of the blood plasma pass from the blood-vessels, with the leukocytes and red blood-cells. The function of this serum is to dilute the toxic substances formed by the bacteria and to neutralize their action. At this stage, due to these changes, there is a great increase in the thickness of the pericementum and the tooth is somewhat elongated in its socket. This is known as *acute pericementitis*. If the conditions continue, destruction of tissue takes place and there is noted between the fibres, small collections of pus. If the inflammatory reaction is prolonged, disappearance of the principal fibres occurs by solution, due to the action of ferments secreted by the polymorphonuclear leukocytes. After the loss of the lamina dura of the alveolar process, the pus thus formed infiltrates the cancellous part of the bone, and an exit to the outer bony plate is provided by one or more Haversian canals.

When the pus reaches the periosteum, one of two events may happen. In some cases, this tissue is lifted from the bone, the pus collecting underneath, in others, by necrosis and tissue solution, a sinus is established through the adjacent tissues to the surface. If the pus be evacuated and the injurious agents eliminated, it remains for the cells of the parts to fill in the areas lost in the process. Fibroblasts and vascular endothelium are formed and the space is quickly filled up. The fibroblasts, as time passes, become more fusiform in shape and elaborate processes which anastomose. The collagen fibrils increase in amount, many of the fibroblasts and blood-vessels disappear, the connective tissue formed becomes denser until in the final stage, it is known as scar tissue (fig. 125).

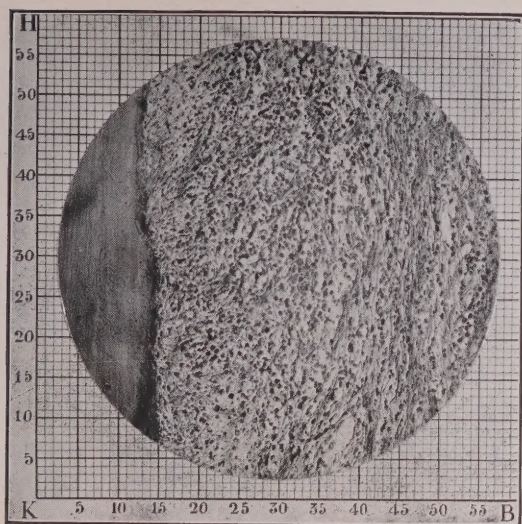


Fig 125— x 188. Acute alveolar abscess.

H K 30 x K B 14, Border of cementum.

H K 35 x K B 27, Polymorphonuclear leukocytic infiltration.

II. Chronic.

Chronic periapical abscesses which remain attached to the tips of the roots after extraction, when viewed macroscopically, present the appearance of small, soft, red or yellow swellings. Upon incision, they prove to be thin connective-tissue capsules or sacs containing pus. Those cases which present no route of discharge of pus are known clinically as blind abscesses, and frequently are formed from granulomata which have undergone purulent degeneration. Where a direct route of discharge is present, in its most common form there is a sinus extending from the abscess to the surface. Quite often, however, the pus finds an exit through a root canal which has offered a path of least resistance. The abscess capsule is made up of bundles of connective-tissue fibres, the arrangement of which is similar to that found in the granulomata. Projections of this connective-tissue capsule extend into the medullary spaces of alveolar bone (figs. 126 and 127).

3. ROOT-CYSTS.

Development of the fifth class of granulomata, previously described, in which there are noted areas containing fragments of degenerated cells and surrounded by squamous epithelium, progresses by dilatation of these lumina. Such dilatation is believed to take place by an increase in the liquid content of these lacunae whereby

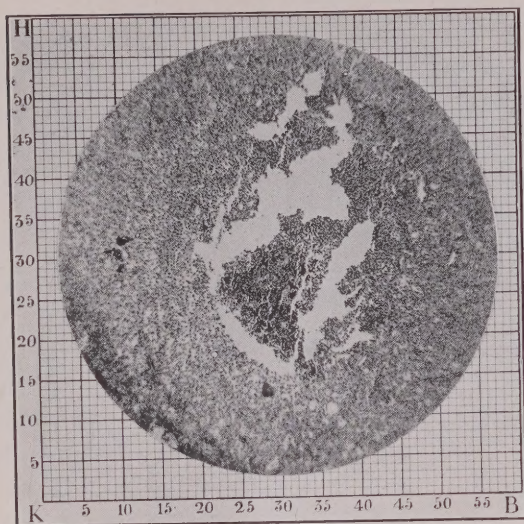


Fig. 126— x 94. Chronic alveolar abscess.

H K 35 x K B 35, Pus.

H K 40 x K B 11, Granulation tissue.

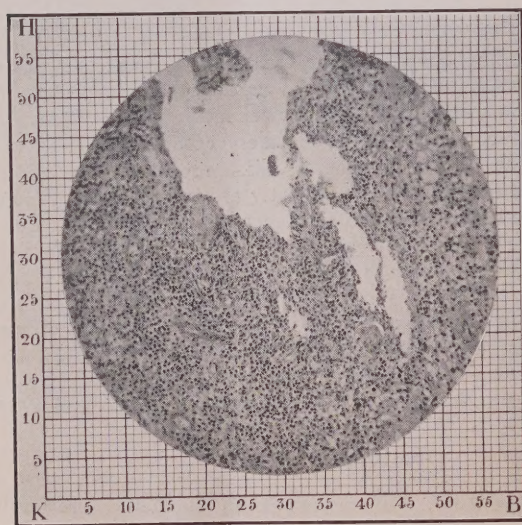


Fig. 127— x 94. Chronic alveolar abscess.

H K 45 x K B 25, Space originally occupied by pus.

H K 20 x K B 27, Granulation tissue.

the connective-tissue layer is pressed toward the periphery. Thus, the outer capsule of the cystic sac is formed. The epithelium is displaced and changed into the smooth membrane of the cystic sac (figs. 128, 129, 130). As the cyst becomes larger through increase of the fluid content, the surrounding bone becomes progressively thinner. Fischer believes that the cystic fluid is due to the mucinous softening of the surrounding connective tissue; that the space lined with epithelial cells is filled by a fluid thus formed which passes through the epithelial layer. It is also his belief that an inflammatory exudate may diffuse through the cellular wall.

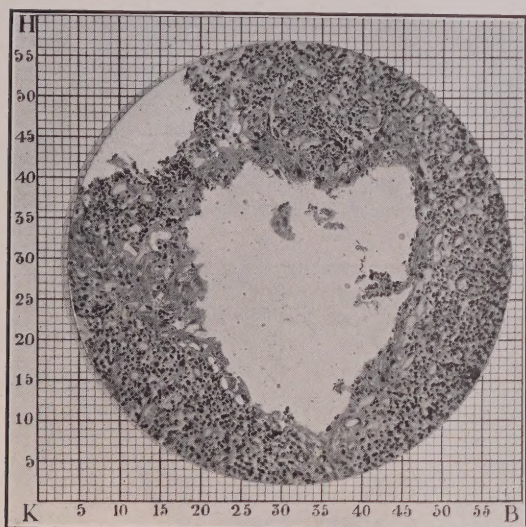


Fig. 128— x 188. Root-cyst.

H K 30 x K B 19, Epithelial lining of cyst.

H K 30 x K B 30, Cystic fluid.

H K 15 x K B 17, Granulation tissue.

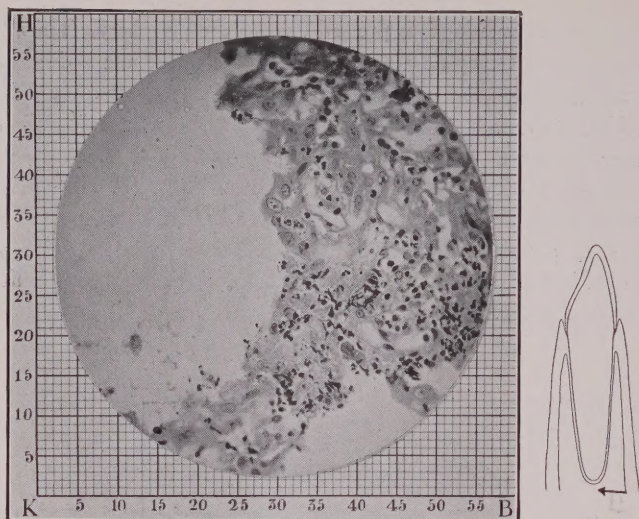


Fig. 129— x 500. Root-cyst. High magnification of the specimen shown in the preceding illustration.

H K 37 x K B 29 } Epithelial cells of the lining of the cyst.
 H K 11 x K B 24 }
 H K 30 x K B 20, Cystic fluid.

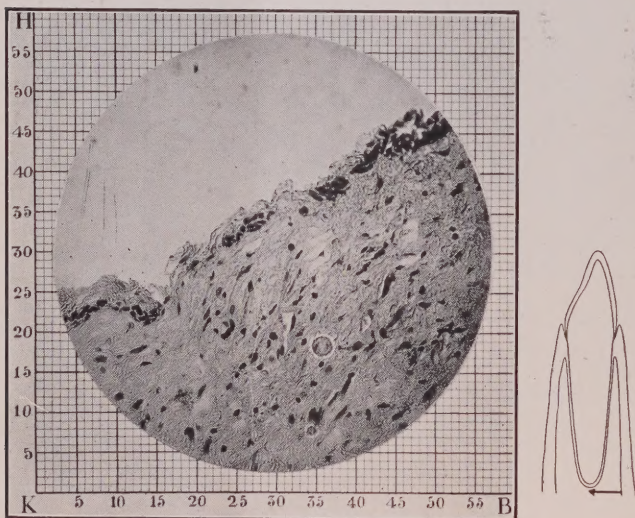


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HAROLD KEITH BOX.

Mechanics of Occlusion

BY G. R. ANDERSON, M.A.

Professor of Physics in Royal College of Dental Surgeons.

INTRODUCTION.

WRITTEN BY HAROLD KEITH BOX, D.D.S., PH.D., F.A.A.P.

Periodontology is the science that deals with the diseases of the periodontal tissues. As in medicine and other sciences, it passes in its progress through periods in which certain theories govern for a time. Research and practice, as a rule, are carried on along the same general lines. With a change of opinion, consequent on improved methods of investigation, a new era is ushered in, the length of which is dependent upon its influence and utility. Scientific investigation of periodontal disease was initiated in a period in which methods of research were dominated by a structural pathology and from the outset was under its sway.

Without the present functional point of view, the judgment of the dental profession, as a whole, has been unfavorable as to the possibility of elimination of these disease processes by treatment. In fact, there has developed for many practitioners, a scepticism towards periodontal therapeutics that, in some instances, has become intensified into an actual nihilism.

When the momentous researches of Pasteur, Lister and Koch introduced a bacteriological period in medicine, there followed in dentistry, a period in which investigators endeavored to prove that bacteria were primary etiological factors in periodontal disease. Physical signs were regarded as expressions of a structural pathology, the result of casual agents of bacterial origin, and treatment was designed to influence these signs as an indication of a change in the pathological condition. In short, the profession has focussed its attention on the treatment of secondary phenomena and the removal of secondary causes of which bacteria are usually the most obvious.

The present may be considered as the beginning of a period of physiological or functional influence. To-day our interest is being centred on the functions of the teeth, and especially the functions of their supporting structures; on the fact that the health of these supporting structures is, in a large measure, dependent upon normal function; and also that departure from normal function renders possible the initiation of the early lesions of periodontal disease.

It must be emphasized, that, in turning to the studies of function,

a study which is making possible great advances in the treatment of periodontal lesions, there is a danger of neglecting an adequate understanding of structure. The correlation between function and structure, in periodontal pathology, is of the utmost importance in the final conception of the whole.

A knowledge of the functions of the teeth and their supporting structures, combined with a viewpoint of their normal and pathological anatomy, has led to the truth, that great regenerative processes are possible; a consequent change of opinion as to the possibility of improvement and obliteration of disease processes when proper measures are taken; and of paramount significance, especially from the standpoint of preventive dentistry, that deranged function is one of the most important primary factors in the etiology of periodontal disease.

The chief function of the teeth and their supporting structures is a mechanical one, the comminution of food into small particles preparatory to assimilation in the digestive tract. The teeth and the supporting structures, therefore, can be regarded as a machine, its normal function dependent upon perfect co-ordination of the teeth in every contact relation.

IN order that any machine may properly perform its normal functions it must be suitably designed; it must possess sufficient structural strength in its various parts to withstand the stresses put upon it with a margin of safety enough to carry an occasional overload without injury; the various moving parts must fit each other accurately and the power must be sufficient for the work and applied efficiently. These conditions being fulfilled, then, with proper care, the machine may be expected to give satisfactory service.

The consideration of the jaws as a mechanism with the mandible as the moving part is the object of this paper. It is proposed to apply to this mechanism the ordinary laws of mechanics, in order to see how far these conditions are met and where they are not met, how improvements might be effected.

The general design embodies two arches of parabolic or semi-elliptic outline, a form that possesses the maximum rigidity for the quantity of material entering into the construction. The upper arch is somewhat more obtuse in outline than the lower, and is also set farther forward, permitting the frontal portion of the upper to project slightly over the lower, thus providing the shearing action necessary in the incisors. The transition from the condition where the upper teeth project beyond those in the mandible to that where they are opposed takes place at the cuspids. The forms of the teeth are adapted to the parts they are expected to play in the process of

mastication, but as this is a matter of common anatomical knowledge, it need not be discussed here.

Coming now to the motive power which is furnished by the muscles attached to the mandible, it is frequently asserted that the design is faulty, that the mandible being a lever of the third class, the work is performed at a mechanical disadvantage, and so on. In the first place, the lever, of whatever class or form, is a plane mechanism, in the ordinary acceptance of that phrase, on which only three forces act. The mandible on the contrary is an extended structure subjected to forces and reactions which are not co-planar and which number more than three.

Figure 1 is a photograph of a representative mandible from a point on a line at right angles to the occlusal plane, and constitutes in fact an orthographic projection of the same. To simplify the calculations, let the following construction be superimposed on the photograph. Draw a line joining the condyles C_1 and C_2 , bisect it at A and draw a perpendicular from the point of bisection A S. This is the median line and should pass between the frontal incisors if the jaw is sym-

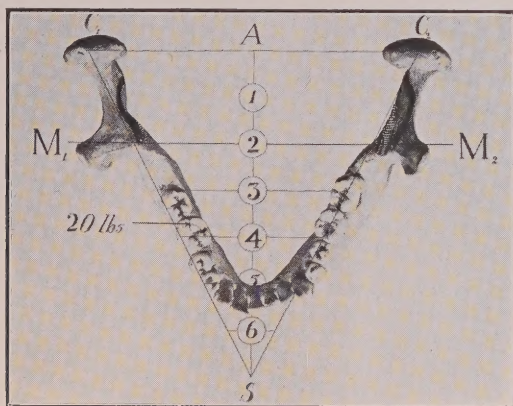


Fig. 1.

GENERAL MECHANISM.

metrical. From the extremities of the line C_1C_2 draw two lines following the line of the molars, these will ordinarily leave the arch at the cuspids and intersect the median line at a point S, the apex of the triangle. From the centre of attachment of the operating muscles draw the line M_1M_2 ; this line will intersect the median AS at a point varying from one-quarter to one-third of the total length from the base, depending on the outline. In the figure this distance is about two-sevenths, and taking this example as typical, the teeth

will be found located about as follows: divide the entire triangle into seven strips of equal width, then division 2 passes through the points of attachment of the masseter muscles, the third molars are found on division 3, the first molars on 4, the first bicuspid on 5 and the line of incisors between 5 and 6.

As an example of the work of this mechanism, let it be required to determine the forces and reactions incident to the crushing of some hard object placed on the second lower right molar, and requiring a force of 20 pounds to crush it. The forces concerned in this action are as follows: The traction of the two muscles acting at the points M_1 and M_2 , the reactions against the condyles C_1 and C_2 and the pressure on the tooth in question, five forces in all, which are parallel but not in one plane. The conditions of solution for a problem of this type are: First, the sum of all the forces must equal zero; second, the sum of all the moments about any line must equal zero. As there are four unknown quantities, four equations will be required for solution. Calling forces acting downward positive and those acting upward negative, the following equations result.

Sum of all the forces:

$$C_1 + C_2 - M_1 - M_2 + 20 = 0. \quad (1)$$

Taking moments about the median line:

$$C_1 \times 7/2 - M_1 \times 5/2 + 20 \times 9/4 = C_2 \times 7/2 - M_2 \times 5/2. \quad (2)$$

Taking moments about the line M_1M_2 :

$$C_1 \times 2 + C_2 \times 2 = 20 \times 1 \frac{1}{2}. \quad (3)$$

Also from symmetry of the action:

$$M_1 = M_2. \quad (4)$$

From equation (3) $C_1 + C_2 = 15$.

$\therefore$ From equations (1) and (4) $M_1 = M_2 = 17 \frac{1}{2}$.

Also from equation (2) $C_1 \times 7/2 + 45 = C_2 \times 7/2$.

$$\text{or } C_2 - C_1 = 12 \frac{4}{7}.$$

$$\text{and } C_2 + C_1 = 15.$$

$\therefore C_1 = 3/14$ and $C_2 = 13 \frac{11}{14}$.

The complete solution then shows that to exert a crushing force of 20 lbs. at the right second molar, requires a tractive effort of $17 \frac{1}{2}$ lbs. by each muscle, and that there will result a pressure at the right condyle of $1 \frac{3}{14}$ lbs. and at the left condyle of $13 \frac{11}{14}$ lbs. Since the total muscular effort is 35 lbs., the indicated efficiency is $55 \frac{5}{7}$ per cent., which by no means shows faulty design.

In a similar way it may be shown that to produce a pressure of 20 lbs. by the incisors, a muscular effort of 55 lbs. would be required, giving an efficiency of only $36 \frac{4}{11}$ per cent. The incisors are, of course, not intended for such work, but, on the contrary, for

cutting softer material, which requires much less effort. If, due to loss of the molars an individual uses teeth farther forward for mastication, he is not giving the mechanism a fair chance.

An examination of the setting of the individual teeth will show that, in the case of the molars, where the greatest crushing effort is required, the pressure is exerted on the crown of the tooth in the direction of the axis, while in the case of the incisors, where only a shearing action is required, the teeth are so placed as to give the maximum cutting effect, but that these teeth can not produce a crushing action except with much greater proportionate muscular effort, and moreover, the lines of reaction are not in the direction of the axis, at least in the upper jaw. The root or roots of the teeth, conical in shape, fit into sockets of bony tissue cushioned by a layer of highly elastic fibre, quite thin along the side of the root, thicker at the apex (Fig. 2). Any pressure exerted against the crown will



Fig. 2.

tend to force the tooth further down into the socket, and the cemental membrane will take care of the stress by a compression proportional to the stress. As has been already pointed out, the layer of protective membrane is deeper at the apex than elsewhere, thus protecting the point of entry of the nerve and blood-vessels. Under normal conditions, the tooth maintains its position subject to the pressure of the opposing tooth or teeth, the reaction of the membrane at the base of the socket and the support of the adjacent teeth and alveolar process on either side. If this balance of opposing forces be disturbed by the absence of any one or more of the reactions, a

shifting of the tooth in the direction of the reduced resistance will ensue.

Passing now to the consideration of the forces acting on any individual tooth, several type cases may be considered. First, in the case of direct impact on a tooth with a single root, where the crown of the tooth in question projects above the general line of occlusion (Fig. 3): Here the tooth is subjected to a constant pressure in

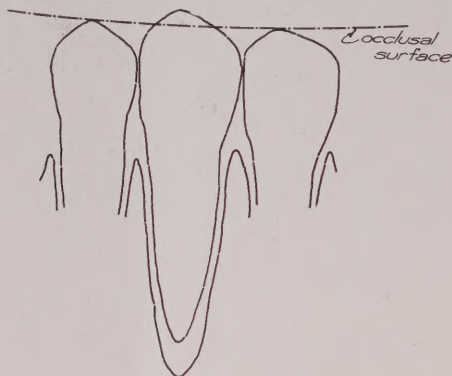


Fig. 3.

the direction of the axis greater than it should be called upon to bear, the result of which will be a compressural stress on the pericemental membrane which will be greater at the apex than along the side in proportion to the length of the root compared to its diameter. Second, in the case of direct impact on a projecting tooth with two roots,

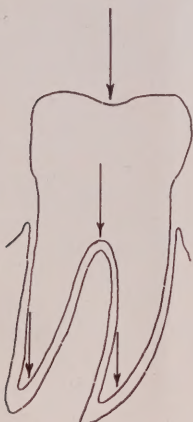


Fig. 4.

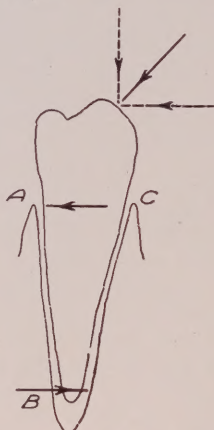


Fig. 5.

maximum compression will take place at the apices of the roots and at the tip of the process between the roots (Fig. 4). Third, oblique impact on a tooth with a single root (Fig. 5). In this case, the pressure may be resolved into a vertical force acting along the axis and a horizontal force at right angles to it. The vertical force, being the normal condition, need not be considered further. The horizontal force, however, will cause abnormal stresses at the points A and B. If the support at the point A be insufficient to withstand the press, the process may break down, causing the tooth to move away from the point C towards A. Fourth, oblique impact on a tooth with two roots (Fig. 6). In this case, as in the previous ones, abnormal stresses will be induced at the points A, B, C, D, with resultant possible separation at E.

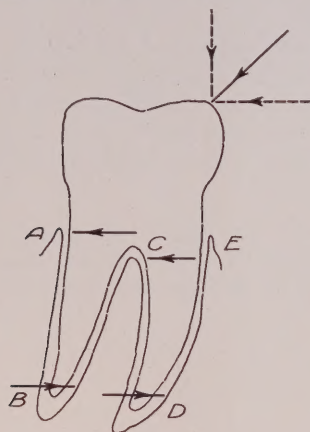


Fig. 6

In the foregoing typical cases, for the sake of simplicity, the action on a single tooth due to a pressure at a point in a definite direction, has been considered without references to the contacting surfaces. In all cases where two surfaces are in contact, the pressures on the surfaces are equal in magnitude, opposite in direction and at right angles to the tangent plane at the point of contact; this is shown in Fig. 7. It will be observed that in this example practically the entire force of the reaction sustained by B is in the direction of the axis, while in the case of A the major portion of the stress is at right angles to the axis. The force R acting on A at the point of contact may be resolved into the two forces R_1 along the axis and R_2 at right angles to it; the latter force will tend to produce a compression strain at the point C and a rarefaction at D. If, however, the direction of the tangent plane of contact be changed, this condition may be

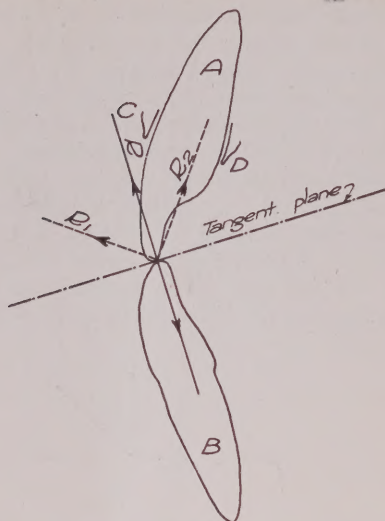


Fig. 7

considerably modified. In Fig. 8, the contact plane, by a slight modification of the contracting surfaces, has been changed in direction, so that each of the two opposing teeth will take a part of the

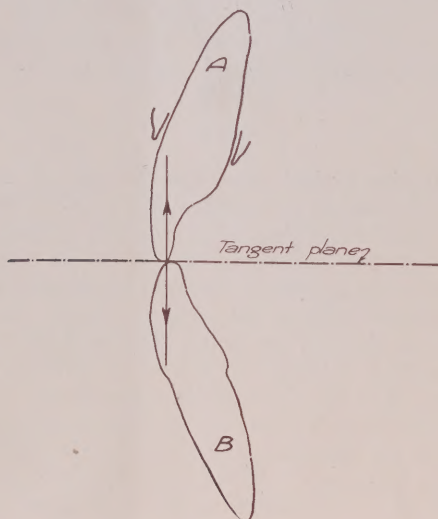


Fig. 8

lateral stress. It is obvious that where the axes of two opposing teeth are inclined to each other, it is not possible to bring about a condition where the entire pressure on both teeth is axial, except by a change of the direction of the axes, but the cross stress may be divided equally between the two or proportioned to the respective resistances which they can offer by a modification of the bearing surfaces.

In conclusion it may be stated:

1. That the general design of the mechanism is suited to the work.
2. That the normal efficiency is satisfactory, considering the various duties to be performed.
3. That where corrections of irregularities in emplacement are to be made, such corrections should be made with due regard to the design as a whole.
4. That modification of the bearing surfaces will relieve abnormal stresses and tend to better working of the whole mechanism.
5. That replacement of missing or broken parts should be made promptly in order not to throw added stress on the remaining members, and to prevent elongation and lateral drifting.

Signs of Incipient Periodontal Disease

Harold Keith Box, D.D.S., Ph.D., F.A.A.P.

SINCE our studies in periodontal pathology have indicated clearly the nature of the disease processes and have justified an optimistic attitude as to the possibility of elimination of these lesions through treatment, early diagnosis becomes of the first importance. It is with the thought of assisting in the early recognition of periodontal disease, that these diagnostic signs are submitted. These have been collected from the clinical experience of the author and have been verified by prominent periodontists. It is not to be inferred, however, that the order in which these diagnostic signs are presented, represents an invariable sequence in the development of periodontal lesions.

Sign No. 1. TRAUMATIC CRESCENT. A crescent-shaped zone of abnormally deep color, never extending completely across the gingival border of the tooth, and being confined as a rule to a segment about $1/6$ of the circumference of the root. It may be superimposed over a mild generalized gingivitis, but frequently occurs in an otherwise healthy gingiva. It is considered to be a sign of a localized circulatory disturbance in the pericementum, and is, as a rule, associated with traumatic occlusion.

Sign No. 2. CONGESTION OF MARGINAL GINGIVA. This zone of congestion extends completely across the gingival border of the tooth. It is regarded as a sign of generalized pericemental circulatory disturbance. It is commonly found in cases exhibiting an end-to-end occlusion.

Sign No. 3. MOBILITY No. 1. This is a degree of mobility so slight as to escape casual observation. It requires careful manipulation and the application of considerable digital pressure, in many instances, for its detection. It seems to be associated with Rarefying Pericementitis Fibrosa, since, in this disease, varying numbers of the pericemental fibres have been replaced by this soft, yielding, new tissue.

Sign No. 4. RECESSION OF THE MARGINAL GINGIVAL LINE. Taking the amelo-cemental junction as a fixed landmark, it is often found that the gingival margin shows an altered relationship to this line. In the average case, the margin of the gingiva is approximately two millimeters above the amelo-cemental line. Recession of the gingival margin toward this line is usually indi-

cative of alveolar crest resorption. For example, a recession of the marginal gingiva which just exposes the amelo-cemental line will probably indicate a crest resorption of two millimeters. Exposure of the cementum will indicate an increased alveolar resorption of a corresponding degree. Figs. 1, 2, 3.

Sign No. 5. **ASYMMETRIC RECESSION OF THE MARGINAL GINGIVAL LINE.** In many cases, recession of the gingival margin involves only part of the normal gingival line. This may occur in the median line of the tooth or on either side of this line, thus

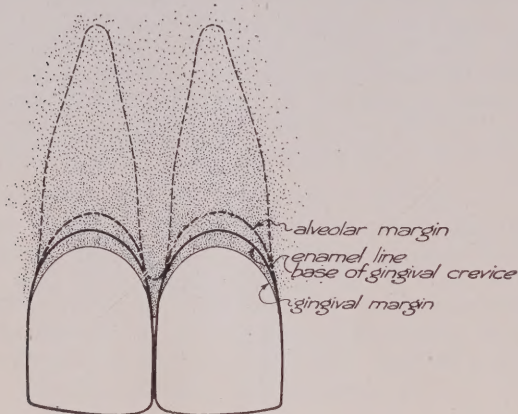


Fig. 1

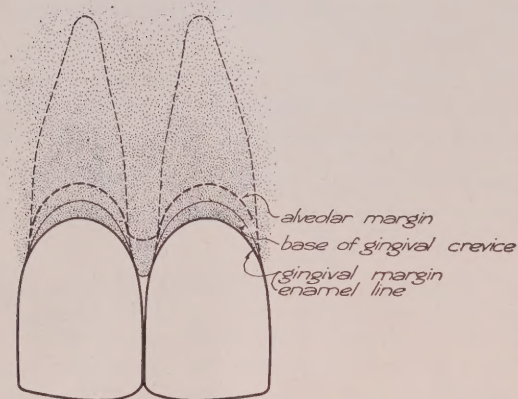


Fig. 2

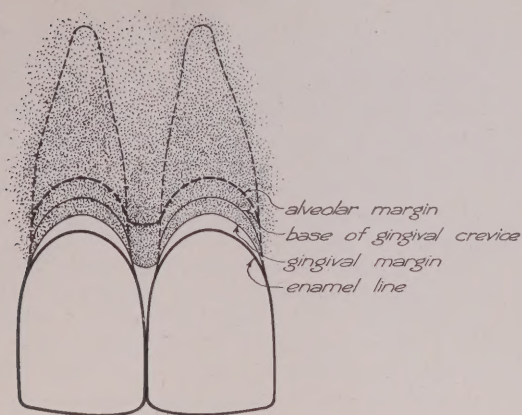


Fig. 3

disturbing the normal symmetry of the curve of the gingival margin. It indicates a localized resorption of the alveolar crest. Figs. 4 and 5.

Sign No. 6. RECESSION OF THE ALVEOLAR CREST LINE. The crest of the alveolar process in the average normal case is approximately two millimeters below the amelo-cemental line, which has been adopted as a fixed landmark. Disturbance of the normal relationship between these lines is a manifestation of recession of the alveolar crest line. This may usually be detected by careful study of the radiograph.

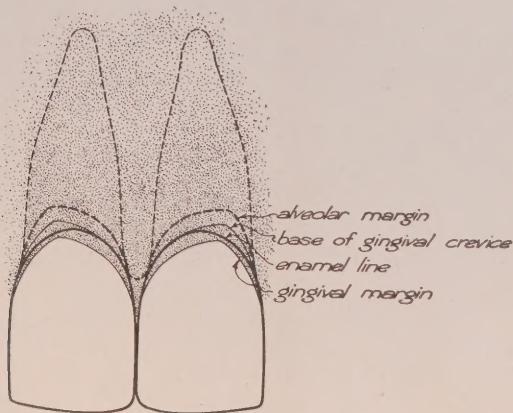


Fig. 4

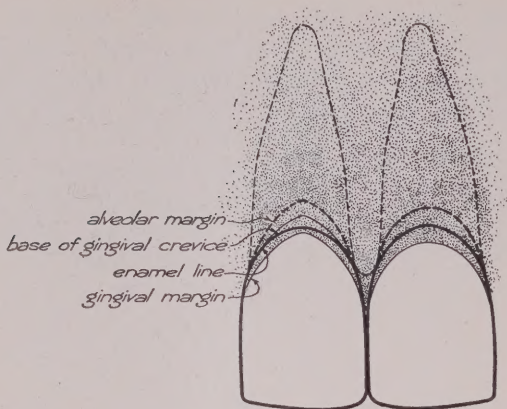


Fig. 5

Sign No. 7. INCREASED RADIOLUCENCY OF THE ALVEOLAR CREST OR LAMINA DURA. This is an indication of a rarefaction of the alveolar bone in these locations.

Sign No. 8. DISTURBANCE OF NORMAL CONTOUR OF THE ALVEOLAR CREST. Frequently the alveolar crest presents in the radiograph a slightly eroded appearance, disturbing its characteristic normal symmetry. This is due to a localized resorption of the alveolar crest.

Sign No. 9. INCREASED WIDENING OF THE PERICEMENTAL SPACE. When complete rarefaction of the lamina dura takes place, there is exhibited in the radiograph, in certain zones, a definite widening of the line which represents the pericemental space.

Sign No. 10. MOBILITY No. 2. When the lamina dura is destroyed to any extent about the tooth, there is, of course, an increase in the soft tissue content between the tooth and the remaining alveolar wall. This naturally permits an increased mobility beyond the normal and beyond that designated as Mobility 1.

Sign No. 11. SHORTENING OF THE CREST OF THE SEPTAL GINGIVA. When an appreciable resorption of the septal alveolar crest has occurred, there will usually take place a concomitant dropping away of the septal gingiva. This will be evidenced clinically by the appearance of spaces between the teeth which were formerly filled with gingival tissues.

Sign No. 12. LINEAR DEPRESSIONS IN THE ALVEOLAR MUCOSA.

These lines are often better shown on models than in the mouth, but may usually be demonstrated in the mouth if the light is properly directed and the mucous membrane is dried. They extend parallel to the long axis of the root and overlie the septal bone. These depression lines are to be differentiated from the normal depressions between the alveoli of adjoining teeth. These lines are characterized by being sharply drawn.

Sign No. 13. STILLMAN'S CLEFTS. These are clefts occurring in the gingival border, occasionally in the centre line of the tooth, but more commonly to one side of this line. Two clefts are frequently noted on the same tooth. Although the underlying tooth surface may not be visible, due to the apposition of the divided tissue, it is invariably possible to pass an instrument through any portion of the cleft to the tooth surface. The writer regards these clefts as essentially small pockets in which the ulcerative process has extended through to the labial surface of the gingiva.

Sign No. 14. ABSENCE OF STIPPLING. In the normal gingiva the color is not a uniform pink, but presents a translucent stippled appearance of alternating spots of lighter and darker shade. When the normal gingiva is dried, it presents a somewhat velvety or mossy surface, indicative, apparently, of a normal circulation in the capillary loops. There is frequently observed a condition in which this mossy, stippled appearance is lost, and the surface is shiny, even when dried, and of a uniform color. The author considers this usually to be a sign of oedema in the gingiva.

Sign No. 15. FESTOONS. When, through the action of a certain grouping of etiologic factors, a hyperplasia of the marginal gingiva is induced, it is frequently manifested clinically by the occurrence of a linear depression outlining the marginal gingiva. The marginal gingiva presents a characteristic uniform thickening, which, however, in the early stages, does not involve the margin itself. In the early stages, too, there is no deviation from the normal color. McCall has called attention to the frequent relationship between these festoons and traumatic occlusion.

Sign No. 16. INJECTION OF BLOOD-VESSELS IN THE MARGINAL GINGIVA. With the aid of an ordinary magnifying glass, there is to be seen, in many cases, a typical dilatation of the blood-vessels in the gingival margin. This is to be considered as an indication of early infection in the marginal gingiva.

- Sign No. 17. **INCREASED DEPTH OF THE GINGIVAL CREVICE.** The normal gingival crevice measures in the average case approximately two millimeters. Any increase in its depth beyond this point must be regarded with suspicion. It is to be regarded as a sign of early pocket formation in the cemental gingiva. This lesion is to be detected only by the use of a suitable diagnostic probe.
- Sign No. 18. **EPITHELIAL NODULES.** There are occasionally to be seen on the surface of the gingivae, small, slightly elevated nodules. They are of a lighter color than the surrounding tissue and in shape are usually round or oval. They usually indicate a period of long-standing venous congestion.
- Sign No. 19. **DISTENDED VEINS IN THE MUCOSA.** In many cases there are to be observed dilated blood-vessels of a purplish color, arising in the septal cemental gingiva, and traceable for a considerable distance in the alveolar mucosa. They usually indicate the establishment of infection in the cemental gingiva at the base of the interproximal crevice.
- Sign No. 20. **PUS-CELLS IN THE CREVICULAR EXUDATE.** Frequently, when clinical signs of pus are lacking, and the gingival crevice is of normal depth, a microscopic examination of the crevicular fluid will reveal the presence of pus-cells. This may safely be regarded as evidence of a suppurative gingivitis.

Articulation for Partial Dentures with the Snow Apparatus and Wadsworth Incisor Guide

W. E. CUMMER, D.D.S.

REVISED BY

DRS. I. H. ANTE and J. A. BOTHWELL

BULLETIN No. EIGHT



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FOREWORD

THE object of this bulletin may be stated in a few words, namely, to give back to the semi-edentulous patient efficient masticating surface without the production of disease in the periodontal tissues of the remaining teeth, by the use of a summary of a well known and comparatively simple system of anatomical articulation. This system is adapted for use in partial denture service and is prepared for the use of the dental practitioner.

As the writer states, there is a particular need for care in avoiding the production of traumatic occlusion in Partial Dentures. The traumatic forces are frequently directed against the periodontal tissues of the remaining teeth, and normal strains often become disease-producing through the loss of teeth.

Forty-five pages of reading matter on this important subject may seem to constitute an unnecessary addition of detail, time, cost, and complication to the process of designing and making Partial Dentures.

The answer is, first, that the writer of this Bulletin has described in detail steps which quickly become second nature through repetition; and second, it is better for the patient and dentist that the denture be RIGHT the first time, without the necessity of one or more make-overs, with the possible production of traumatic occlusion, and the initiation of periodontal disease about valuable teeth.

Traumatic occlusion is responsible, in the opinion of the writer, for at least 40% of natural teeth lost today, from all causes. Much of this traumatic occlusion is due to bad design, and construction of Partial Restorations, and is largely produced through bad articulation and interference of porcelain which, in most cases, throws momentarily the whole force of mastication against two or more teeth, often in a direction not coincident with their long axes.

It is therefore the belief of the writer, that a study of these pages will well repay the dentist who will undertake it, in the *real* reward that comes from his labors, and the *real* foundation for success in practice:—the happiness and health of his patient, so far as his profession enables him to contribute toward this ideal.

HAROLD K. BOX.

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Articulation for Partial Dentures with the Snow Apparatus and Wadsworth Incisor Guide*

W. E. CUMMER.

Revised, Drs. I. H. Ante and J. A. Bothwell.

ROYAL COLLEGE OF DENTAL SURGEONS.

Drawings by Dr. H. H. Cummer and by courtesy of Snow Dental Mfg. Co., Dentists' Supply Co., and S. S. White Dental Mfg. The writer also acknowledges material assistance in the preparation of illustrative material to Mr. W. V. Byrne, and of photographs, to Farmer Bros., Toronto.

1. *Anatomical Articulation for Partial Dentures.*

The principles of Anatomical Articulation in the design and construction of full upper dentures are becoming well known to the Dental profession. These include, among other things, the measurement of habitual jaw movement, with artificial teeth chosen and arranged so that there is always a balancing contact, and that each cusp plane functions with another, during function.

Neglect of these principles in full denture construction may result in a so-called cusp trauma, or interference, which is due to such causes as interfering porcelain, and consequent lack of balance. The shock, or trauma, during mastication, is transmitted to the denture bases, which, among other things, irritates the peripheral tissue and tends to unseat the dentures, and for which the dentist often will trim down the margins, failing to discern the real cause.

In partial denture work this cusp trauma, due to lack of observance of the principles of anatomical articulation, is not only reflected upon the peripheral tissue, but may, with more destructive results, be directed against the periodontia of two or three teeth which retain the piece and such other teeth which, in some designs, act as a brace against lateral stress. The writer would submit that, even for this reason alone, the building of partial dentures should be given at

*Superseding mimeograph sheets on this subject, as issued to the students, R.C.D.S. It is presupposed but it is not essential, that the reader is familiar with the scientific basis for anatomical articulation, and the general sequence in articulation technic with the Snow apparatus for Full Dentures, in order to derive practical value from the study of this Bulletin.

least the same, if not more care in articulation as full dentures. Hence the subject matter which follows.

2. *Difference between Full and Partial Articulation.*

A main difference exists in the methods of management between the Full Upper and Lower, on one hand, and all other artificial restorations, as Single Full Dentures, Partial Dentures and Bridgework.

This difference is based on the fact that, in Full Upper and Lower Dentures, there are no remaining natural teeth, and the dentist may place all of the teeth in that position which is in closest co-ordination with jaw movements. In all other types, however, there are remaining teeth, which complicate the problem, and whose sulcus angle, cusp forms and positions make it necessary that artificial adjacent teeth be made to conform to these natural teeth, so that habitual mandibular movements allow both natural and artificial teeth to pass one another in function without interference or consequent trauma, which directly follows any interference in the lateral movements of mastication.

3. *Apparatus considered.*

In addition to a working knowledge of mandibular movements, apparatus or its equivalent, as described below, is a minimum requirement. In this article, this apparatus will be considered first, with the method of use immediately following.

Apparatus, minimum requirements.

- (a) An articulator which approaches sufficiently well for practical purposes in its movements, the natural jaw movements, with a simple means or reproducing mandibular movements.
- (b) An instrument for correctly locating the models in the articulator.

The dental profession has at its disposal various articulators with which fine results are possible, and which embody the most advanced thought of the day. The instruments of Gysi, Munson, Hall, Hanau, among others, embody advanced and scientific thought, if, perhaps, the conclusion reached by each designer are not identical.

For, however, the practical purpose of the student, and for the practitioner who wishes to make a beginning in articulation for partials, from which he may readily step into a more advanced technic, the writer will propose a well known and widely used apparatus of moderate cost, as follows:—(a) Articulator—The Snow New Century Articulator, with the Wadsworth Incisor Guide, and (b) the Snow Face Bow for locating the models. For use with these will be proposed a simple system of right and left check bites for measuring the movements of the jaw, and for the setting of the instrument, so far as it may be set, to these movements.

4. *The Snow New Century Articulator.*

This well-known instrument is shown with its parts in Fig. 1. Its movements are guided by two adjustable condyle slides, adjustable approximately to natural condyle inclinations, which cause the condyles of the articulator to move in a straight line rather than the curved path in Nature. In most cases, this small discrepancy may be taken up in final adjustment in the mouth.

These mechanical condyles are set apart on the articulator at a distance of approximately 10 centimetres, or 4 inches, on a horizontal plane, in which the rotation axes of the articulator lie. There is consequently no adjustment for varying rotation axes,* which discrepancy, if noticeable, must be taken up as far as possible, in final adjustment to the mouth, by carbon paper and spot-grinding.

The Wadsworth Incisor Guide provides a guide to the incisor region and consequently three point support for the articulator, referred to at length later in this article.

5. *The Snow Face Bow and its Purpose.*

All anatomical articulators have a joint mechanism which corresponds in position and function, more or less accurately to the temporo-mandibular joint of the patient.

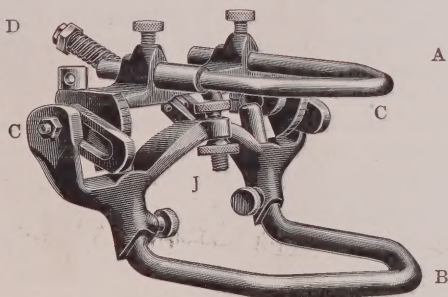


Fig. 1.—The Snow New Century Articulator, with plain model supports. Special lower and upper model supports are required with the Wadsworth Incisor Guide. These are shown, Fig. 13.

A-B. Upper and lower model supports. These should be kept parallel to the occlusal plane and to one another.

***Rotation Axes.**—Considering the habitual movements of the jaw on a horizontal plane (the plane of actual mastication), Gysi has shown that these movements are from centres, or better, axes, not coincident with the condyles, as was originally supposed. These axes lie without and within the condyle heads, at varying positions, in different individuals. Artificial teeth for an individual with widely separated rotation axes made on an articulator with rotation axes closer together would result in a discrepancy in the passage of the cusps in the side movements of mastication. The rotation axes on the Snow Articulator are 10 cm. or 4" apart, which is the mean between the extreme positions, as now understood. Dentures built on the Snow Articulator should be checked with carbon paper on insertion to correct this discrepancy, if it occurs. The cases in which it would occur are those in which the position of the rotation axes in the patient's mandible does not correspond with the average, as built into the Snow Articulator.

Fig. 1 (continued from page 9).

The second score from the top is 0° , the third is $+10^{\circ}$, the fourth $+20^{\circ}$; and the upper or first score is -10° , or 10° above the occlusal plane. This, if found, is called a reverse condyle path.

C. Condyle mechanism or joint slides.

D. Retracting spring which keeps the condyle in the Glenoid fossa, as these are represented on the articulator. This is disconnected while the joint slides are being set in position from the check bites.

J. Adjusting screw which holds the separation between the models when mounted on the articulator. With the Wadsworth Incisor Guide this screw does not function, except temporarily.

The Snow Face Bow (Fig. 2) is for the sole purpose of locating plaster or stone models of teeth and jaws in the anatomical articulator, in the same relation to the articulator joint-mechanism as the original natural teeth and jaws bear to the patient's temporo-mandibular articulation, or joint mechanism. Other Face Bows, modelled after the Snow Face Bow, are also in use for this purpose.

6. Restorations Made Without the Use of the Face Bow.

For obvious reasons, it is inexpedient for dentists to arrange the teeth on the wax bases directly in the mouth. If this were convenient, that is, to use the patient's jaws as an articulator, there would be no need for either Face Bow, or articulators, anatomical or otherwise.

Hence it becomes expedient for dentists to use Articulators. Anatomical Articulators are those which attempt to reproduce all jaw movements, in distinction to plain line Articulators which have an opening movement only, like a hinge. Anatomical Articulators are (1) adjustable (within limits) to the movements of the jaw, for example, the Gysi adaptable, Hanau, Snow, or (2) non-adjustable, or adjustable within smaller limits, chosen within an average, as the Hall, Monson, Gysi Simplex and others.

For all types of Anatomical Articulators, aiming, as they do, to reproduce jaw movements, it is obvious that, even with the most accurate reproduction of these movements, in an Articulator which is most capable of reproducing these movements, failure will result when the distance and position of the models and jaws is guessed at, and the model placed in the Articulator without the Face Bow or its equivalent. That there is a considerable range in this distance and position may be noted. Fig. 3.

The result is that, because of this discrepancy, the teeth in the articulator may move in a path not in harmony with habitual jaw movements. Consequently, when they reach the patient, while seemingly correct in central occlusion, in other positions an interference takes place, which tips the plate, drives its margin into parts of the soft tissues, or like difficulty which the patient sums up—"Doctor, I cannot chew with these teeth."

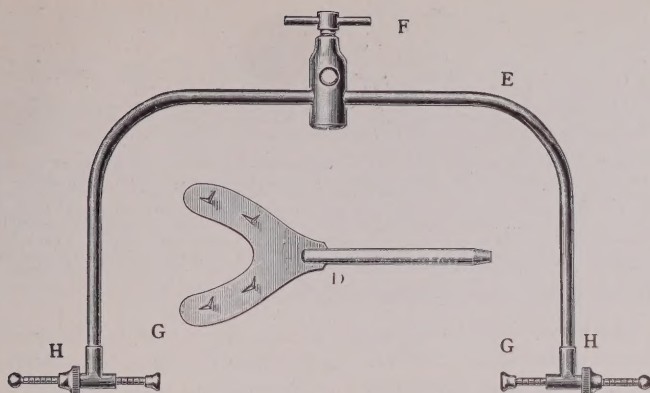


Figure No. 2—The Snow Face Bow with stem No. D, as described in text. The Face Bow has a body and a stem. In the body are the sliding condyle rods, the contacts of which (G) fit on the patient's skin immediately over the condyles, and are clamped there by the knurled nuts H. On the front of the body is a binding clamp (F) which binds the bite stem (which, in turn, bears the model and trial plate) to the body of the Face Bow. D is one of the bite stems, as described in the text.

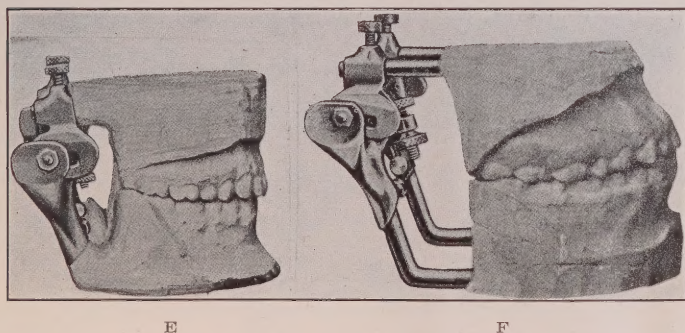
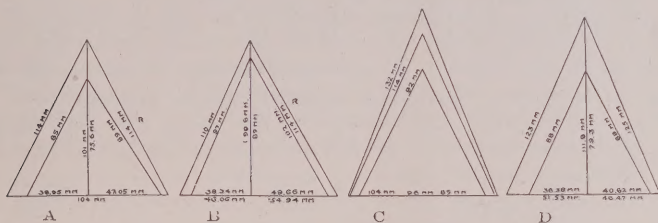


Fig. 3—Range of Distance between Condyles and from Incisors to Condyle. Figs. A, B, C and D represent the result of the examination of Dr. George H. Wilson, who measured nearly three hundred mandibles at the Smithsonian Institute at Washington.

A. Diagram showing largest and smallest triangles (whites) contrasted. Observe difference of nearly an inch at the apices. Larger figure, sides 114 mm., base 104 mm., perpendicular 101 mm. Smaller figure, sides, right 89 mm., base 81 mm., perpendicular 75.6 mm.

B. Scalene triangles; large white mandible sides, 114-110 mm., base, 101 mm. Small figure, white mandible, sides, 102-97 mm., base 88 mm. Note distance of perpendicular from centre of base of larger figure.

C. Three isosceles triangles. Largest figure, Australian, sides 132 mm., base 104 mm. Middle figure, large white mandible, 114 mm., base 96 mm. Smallest figure, small white mandible, 92 mm., base 85 mm.

D. Scalene triangles: Large figure, Indian mandible, sides 125 and 123 mm., base 98 mm. Small figure, Egyptian mandible, sides 89 and 88 mm., base 79 mm.

In these triangles, the range of distances is considerable, irrespective of the range in positions.

Figures E and F are illustrative of cases from life which show a wide contrast in the sizes of the mandibles. Fig. E is from a young lady below the average size, who was the possessor of an unusually perfect set of natural teeth. In her case the perpendicular measurement from the intercondyloid line to the mesial incisal space was 3% inches. Fig. F is from a man, who attracted considerable attention a few years ago from his ability to take four billiard balls in his mouth at once. This individual was of medium height and built with a small head and considerable prognathism. His measurement from the condyle to the mesial incisal space was 4% inches, an inch more than that of the former example.—Snow "Anatomical Articulation."

The above evidence is ample to convince a sufficiently decided variation in the *relation* between the jaws and the mandible. Without the Face Bow or its equivalent it is impossible to reproduce this, and consequently failure may result from guesswork. In other words, dentures made for case E (Fig. 3), set in the articulator the same position as in case F (Fig. 3), could not function properly.

7. Summary of Technic of Snow Face Bow.

A summary of the proper sequence in the use of the Face Bow which occurs during the taking of the bite in the *construction* of a restoration, here follows. In partials, this sequence occurs after the framework is constructed, the trial plates built out to contact, and to other dimensions herein stated, and the trial plates with their models are about to be mounted in the articulator, as in Figs. 25, 26 and 27.

(a) Locate condyle heads.

(b) Apply proper bite stems to (A) Upper Natural Teeth, or (B) Full Upper Denture Trial Plate, or (C) Upper Teeth with Partial Denture Trial Plate, as may be present in the mouth.

(c) Slip Face Bow Body over Bite Stem Rod, and adjust Condyle Rods to Condyle.

A description of each of these steps here follows:



Figure No. 4—The position of the Condyle Head on the external contours.

Usually the condyles are found about 1 centimeter in front of the tragus of the ear, and in the direction of the outside canthus of the eye."—Gysi, Cosmos, 1910.

8. Locating Condyle Heads.

This may be done by asking the individual to close the teeth or trial plates together in occlusion. The index fingers of each hand are then placed over each condyle and the patient is asked to open and close rapidly. The condyle will be felt to move back and forth into its rest position. This is the position of the condyle which is desired and which may be then noted mentally or by a mark on the face. This will usually be found to be 1 centimeter ahead of the tragus of the ear and in line with the canthus of the eye, as noted by Professor Gysi, Figure No. 4.

9. Applying the Proper Bite Stem.

The bite stem is the intermediate piece, attached on one end to the model, either directly or through the trial plate, and on the other end to the body of the Face Bow, by the clamp F, Fig. 2.

The bite stems of the Snow Face Bow are numbered A, B, C and D, and are for different conditions, as noted Figs. 5, 6 and 7. The bite stem of the Snow Face Bow is practically *always fastened to the upper trial plate*, teeth, or teeth with trial plate, as noted below.

10. Bite Stem "A" and its Use.

The Bite Stem No. A is a semi-circular fork mounted on a stem which, similar to each of the other bite stems, fits the clamp on the body of the face bow with a running fit. This semi-circular fork is intended to be heated and buried *to the hilt* in the anterior surface of the trial plate, as Fig. 5, B and C. This is necessary to secure the firm attachment of the stem to the trial plates.

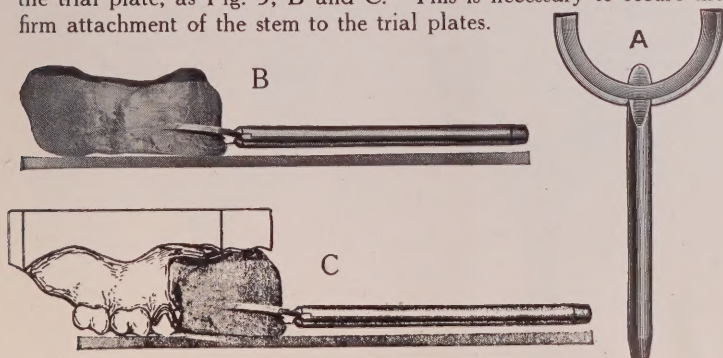


Figure No. 5—Bite Stem "A" and Its Use.

(A) Shows Bite Stem No. A, (B) the Bite Stem No. A inserted in a Full Upper Trial Plate. Note that the entire semi-circle is buried to the hilt in the wax and that the whole stem is in line with the occlusal plane. If not buried, the stem may move on the trial plate and the relation lost. (C) Use of Bite Stem No. A in the trial plate of an Upper Partial with large anterior loss. The clasp may be noted on second bicuspid, and the metal framework attached to the clasp is complete, under the trial plate, in a similar manner to the example shown in Fig. 22 D.

Bite Stem No. A is intended for us on—

1. Full Upper Trial Plate against any Lower Combination of Teeth, Denture, Crown or Bridge.
 2. Partial Upper Trial Plate with sufficient amount of Trial Plate in the anterior to receive Bite Stem No. A, against any Lower Combination of Teeth, Denture, Crown or Bridge.
11. *Bite Stem A May Remain in Position While Both Upper and Lower Models are Affixed to Articulator.*

In Figure 5, B and C, it may be noted that no part of the Bite Stem A comes between the Upper and Lower Teeth or trial plates.

This makes it possible to affix both upper and lower models to the Articulator before removing the Face Bow. This is possible only with Bite Stem A.

12. *Bite Stems "B" and "C," and Their Uses.*

Bite Stem B is a stem which fits the Face Bow body with a running fit and which has a form similar to a shallow impression tray attached to a rod in place of the ordinary impression tray handle. Into this tray soft wax may be introduced and pressed against the occlusal surfaces of the upper teeth or upper teeth and trial plate, similar to a shallow impression. Into these depressions the models are placed in the Articulator during the process of mounting in the Articulator.

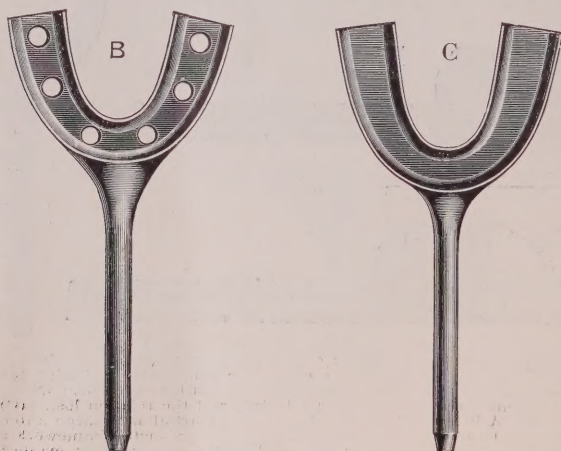
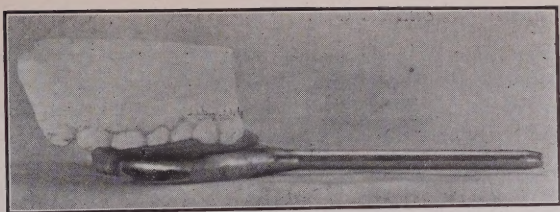
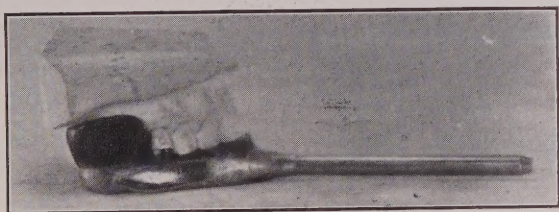


Fig. 6



C



D

Figure 6—Bite Stems "B" and "C," as described in text. These are more or less interchangeable, the holes in "B" assisting in the retention of the wax. "D" shows the use of the Bite Stem C or D in mounting a model of Full Upper Natural Teeth in the Articulator.

"E" shows the use of the Bite Stem C or D in mounting a model, a partial upper denture, with anterior teeth present, preventing the use of Stem A.

Bite Stem B and C are indicated in:—

1. Partial upper with insufficient anterior trial plate for Stem A, against and lower combination, (Full Lower, Partial Lower, Bridge work, or Natural Teeth).
2. All, or nearly all, upper teeth in position, against any lower combination as above.

This stem is used by heating the tray end, and flowing wax so as to cover the shallow depression with an adhesive film of wax. Soft wax and applied above and sometimes below, pressed into the patient's upper natural teeth, or teeth with trial plate, and the lower teeth, if suitable, may be pressed against it to hold it in position. The Face Bow is then applied as in Section 16.

13. *Bite Stem "B" Must be Removed After Upper Model is Fixed in the Articulator.*

Inasmuch as the Bite Stem B occupies space between the lower combination of teeth, dentures, crowns, or bridges, as presenting in the patient, it must necessarily be removed after the Upper Model is luted or affixed to the Articulator, and before the Lower Model is luted or affixed. This is shown in Figure 8.

In Bite Stem A, as already noted, this is not necessary, and both models may be luted to the Articulator before the removal of Bite Stem A.

14. Bite Stem "D" and Its Use.

The Bite Stem D is a flat metal stem with spurs, and is shown in Fig. 2, D for those who prefer it. The use of the D Bite Stem avoids defacement of the Middle and High Lip Lines, which are traced upon the front of the Upper Trial Plate, as may be seen, Fig. 23.

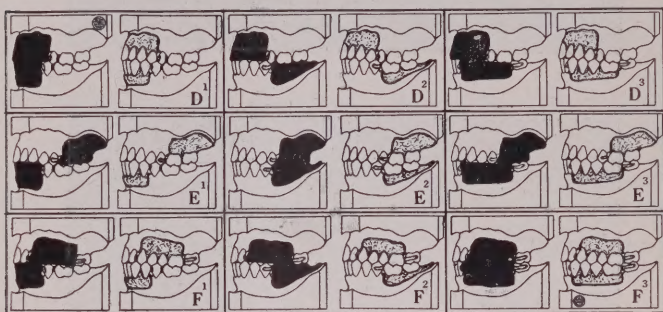


Fig. 7—Selected Trial Plates and finished cases, showing choice of Face Bow Stem.

D¹—D²—D³—Use A or B Stem.

E¹—E²—E³—F¹—F²—F³—Use B Stem only—No wax in Trial Plate for A Stem.

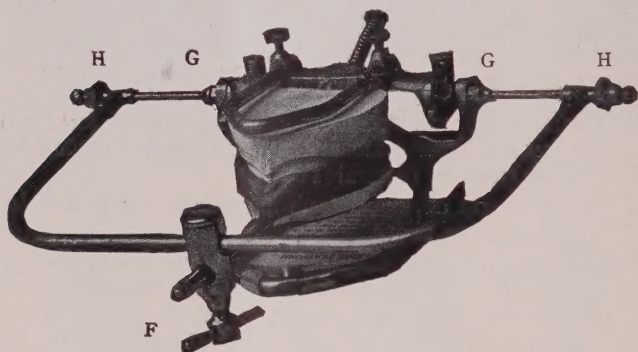


Figure 8—Mounting with Stem B or C.

This figure shows the upper model to be mounted in the Articulator. Immediately after this is done the Face Bow and Stem B or C are removed, and the Lower is set into position from prints on the Lower Trial Plates, facets on the lower teeth, or similar, depending on conditions in the Lower. This shows all the Upper Teeth in position, hidden, however, by the wax on Stem B or C. (In this instance Stem B is used because teeth are present beneath the wax. If Bite Stem "A" is used, model is fitted into its Trial Plate. If Bite Stem B or C is used, model is fitted into prints in wax.)

15. Applying the Bite Stem to the Trial Plate.

Condyle Inclinations and other measurements on a Vertical or Transverse Plane are measured in degrees of an angle from the Occlusal Plane. On the Snow and other Articulators having adjustable Condyle paths, the Model Supports or Bows are set parallel to

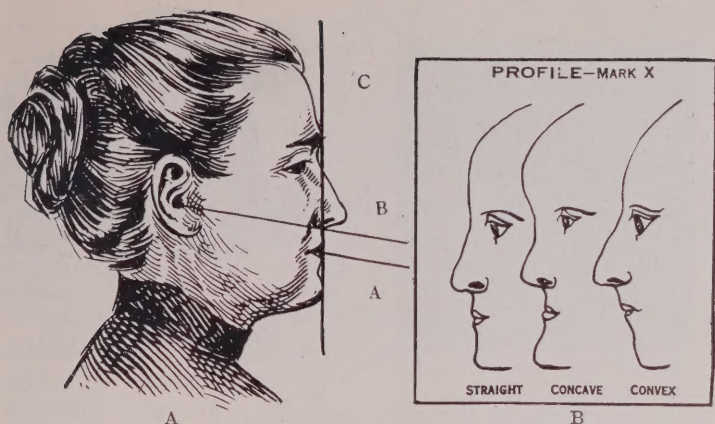


Fig. 9—The Facial Line and Occlusal Plane.

The Occlusal Plane cuts the facial line ordinarily at about 70°. A. Occlusal Plane. C. Facial line, which touches the forehead, chin, and in a regular profile, divides the nose approximately in half, in the convex profile comes behind the nose, and in the concave profile may occur ahead of the nose. D. Profile Drawing from the Dental Dept. University of Pittsburg, courtesy Dr. H. W. Wright.

the Occlusal Plane, for convenience in reading these angles on the Instrument from the scores or graduations, as noted, Fig. 1.

Therefore:—If the bite stem be set parallel with the base of the Upper Trial Plate in, for example, a Full Upper and Lower, restoration, which base is trimmed parallel with Occlusal Plane, and projects from the patient's mouth as line A, Figure 9, the result will be that the occlusal plane of the patient and the Articulator will be the same, and that the number of these degrees of inclination of the Condyle path on the Articulator may readily be read. In cases other than Full Upper, difficulty sometimes occurs in this regard, but so far as possible the Bite Stem should leave the patient's facial line as in Figure 9, line A, or coincident with the Occlusal Plane.

16. Applying the Face Bow to the Patient.



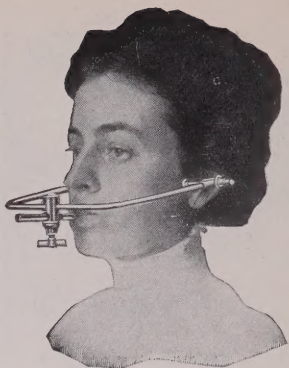
A

Fig. 10 (over).

B



C



D

Fig. 10—Applying the Face Bow. The position of the dentist in applying Face Bow, is directly in front of patient.

A—With bite stem in position, as described, and the condyle rods pushed out.

B—After the face is centred in the Bow, lifting it a little to the left.

C—Locking one side, after which the other side is locked, directly in contact with the face.

D—Face Bow in position, face in centre, as described in the text.

(These drawings from "Professional Denture Service," Clapp and Trench.)

To do this the dentist stands directly in front of the patient and opens the contacts of the sliding condyle rods (Fig. 2, G) until they touch the main frame E, and, holding the bow in both hands just behind H-H, it is then brought to position, allowing the rod of the bite stem, which projects from the patient's mouth, to pass through binding screw, Fig. 2, F, as in Fig. 10, A. As soon as the condyle rods are opposite the condyle heads (Sec. 8) they are lightly pushed inward by the thumbs until the face is equidistant from each side of the Face Bow. This means that the scores on the Face Bow will count the same both left and right. Lift the Face Bow off the face slightly to, say, the left side (10-B) and tighten condyle rods on that side first with binding screw H, (10-C) return to face and tighten other side; this time in contact with the face on both sides. Then finally tighten binding screw at F, (if more convenient have patient tighten at F). As soon as F is tight, the rods G may be disengaged by slacking off binding screws H-H, Fig. 2, and Face Bow, attached to Bite Stem, with or without Trial Plates, may be removed. Thus, the patient's head becomes centred in the Face Bow. In the next step the Articulator takes the place of the patient's head in the Face Bow.

17. Mounting the Model on the Snow Articulator.

The general plan is as follows:—immediately after the removal of the Face Bow, Stem, etc., from the mouth, the condyle rods (Fig. 8, G) are pushed into their fullest extent and locked with lock nuts H. The Face Bow will now nicely spring over the knobs on the

Joint Slides of the Snow Articulator as Figure 8. The Articulator is prepared by inserting suitable model supports (which are set parallel to one another) and the whole slipped on the tin shoe* as in Fig. 8, so that the whole will stand upright without falling. The Face Bow, Bite Stem, and models (with or without Trial Plates), are now inserted in the Articulator and the binding nut F, is raised, if necessary, by a piece of plaster or similar, so that the Bite Stem Rod, (which is coincident with the Occlusal Plane), and Articulator Bows are all parallel to the Occlusal Plane of the Patient. This makes it possible to subsequently read the condyle inclinations on the articulator in degrees from the Occlusal Plane, as already noted.

The Upper model, whether working model or antagonizing model is luted to Upper Model support, first having been thoroughly moistened before applying the plaster which lutes or joins it to the Upper Model Support. This having been accomplished, bite Stem B, if used, is removed with the Face Bow, the Tin Shoe* is removed, the Articulator inverted, and the Lower Cast, with or without Trial Plate, is adjusted to the Upper Cast, also with or without Trial Plate. It is then moistened and luted to the Articulator. (If the A Stem is used, both models may be luted without removal of A Stem on Face Bow.) When the Wadsworth Incisor Guide is used, there is a slight modification in the technique, as hereinafter described.*

18. *The Wadsworth Incisor Guide Attachment for the Snow Articulator.*

This device may be now used with the Snow Articulator and greatly increases the efficiency of the Snow Articulator in Partial Denture work.

In Partial Denture work, the average sulcus angle of the artificial teeth should correspond to the average sulcus angle of the remaining natural teeth. In addition to this, the Articulator should be adjusted to move in harmony with this common sulcus angle of the artificial and natural teeth. Both of these are necessary so that the artificial and natural teeth may pass without interference during function, avoiding Traumatic Occlusion.

This is accomplished, from a practical standpoint, by the above combination, and, in addition to this the Articulator is mechanically guided at three widely separated points (the two condyle joint slides and the Wadsworth attachment) which are all set to the patient's movements by check bites) rather than at three points in close relationship, (the condyle joint slides on the supporting screw J of Fig. 1.) This results in additional stability to the Articulator, similar to that afforded to a tripod by its third leg well extended and, in many cases prevents the possibility of closing the bite if Full Dentures or unsupported Partial Dentures enter into the restoration. The Wadsworth incisor guide is also useful in many cases of Full

*The Tin Shoe is not used when the Wadsworth Incisor Guide is used with the Articulator, as subsequently noted, Fig. 27.

Upper and Lower Denture work, as for example, cases in which unusual degree of overbite is required. Also, the breaking and wear of stone teeth in Partials is eliminated, when incisal movements are guided by this appliance in the articulator.

19. *The Sulcus Angle of the Artificial Teeth Should be Identical With That of the Natural Teeth.*

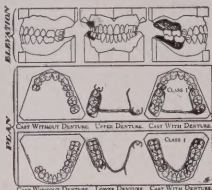


Fig. 11—Plan and Elevation of case used to illustrate the necessity for uniform Sulcus Angle, and Articulator adjustable for it, as shown in Fig. 12. Sulcus Angle of the Remaining Teeth is as above, 120 degrees. Sufficient Natural Teeth in this case remaining in articulation in the patient's Upper and Lower Mouth to establish Jaw Movements also at the angle of 120 Degrees.

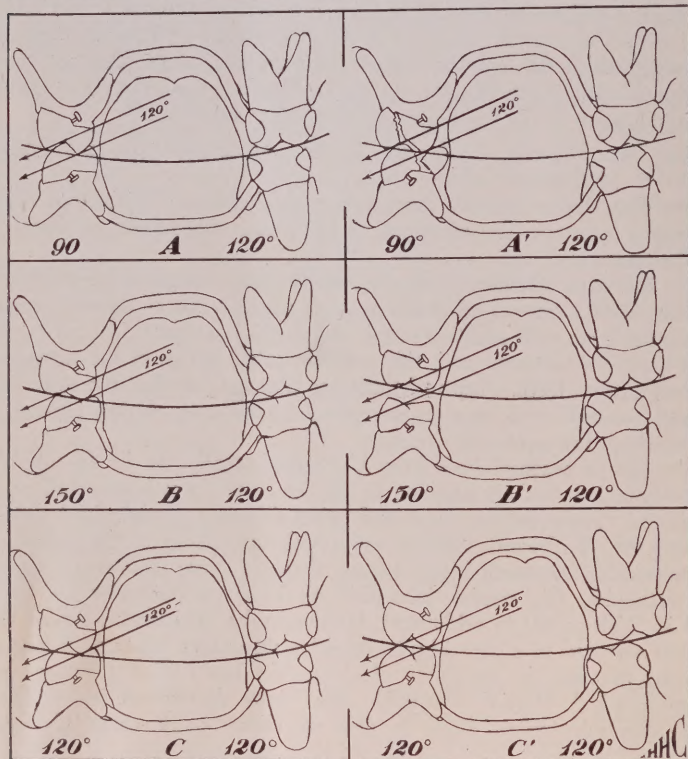


Fig. 12—A Diagrammatic section, looking backwards towards the molar section of cases in Fig. 11. The remaining natural teeth are shown in each of the

six drawings on the reader's right hand, while the artificial teeth are shown on the reader's left hand. In each case the Sulcus angle of the remaining natural teeth is approximately 120 degrees.

Sections A and A¹. Section A shows Dentures as in Fig. 11, made with artificial teeth having sulcus angle of 90 degrees (which is a lesser angle than that of the natural teeth). In central occlusion, no interference is noted, but in side motion, (A¹) an interference takes place which may break the teeth,—or drive the bicuspid and molar anchor teeth laterally and break down their periodontia (pericementa and bone),—or strain the appliance,—or drive the saddle into the gums with irritation,—or any or all of these and other sequelae in various combinations.

Sections B and B¹. Section B shows Denture as in Fig. 11, made with artificial teeth having a sulcus angle of 150 degrees, which is a greater angle than that of the Natural teeth.

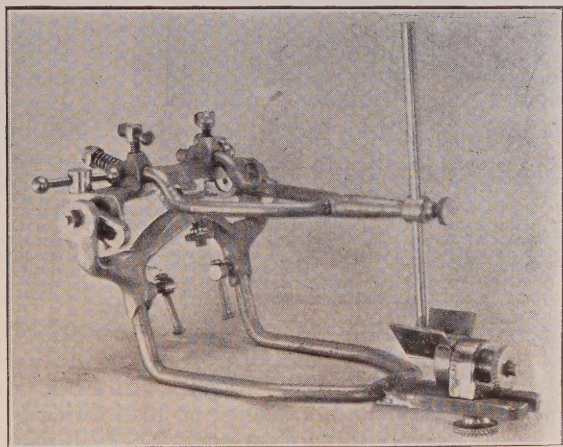
In Central Occlusion (B) no interference is noted, but in side motion (B¹) the cusps slide out of function, losing efficiency, and also balancing contact.

Sections C and C¹ show a denture as in Fig. 11 made with the Sulcus Angle identical with that of the Natural Teeth, namely, 90 degrees.

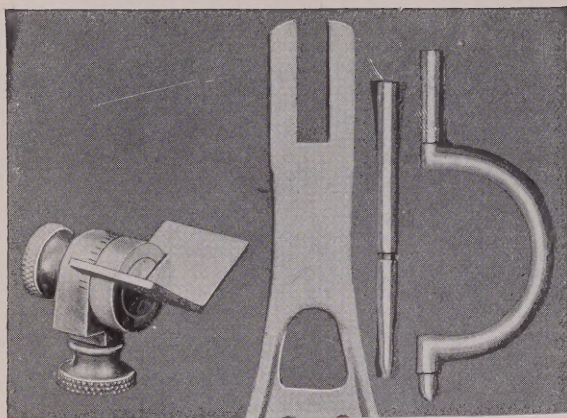
In Central Occlusion no interference is noted, and in side motion (C) both balancing contact and function obtain.

An examination of Figs. 11 and 12 will illustrate this important essential. It will there be noted that of the two discrepancies possible, namely that of having the sulcus angle of the artificial teeth greater or smaller than that of the natural teeth, that the error of the artificial sulcus angle too small (Fig. 12, secs. A and A¹), is the more serious. For example, the use of the so called deep bite teeth, with approximately 90° sulcus angle, as used in Full Upper and Lower work, would have this result if used in many Partial Dentures, against which the remaining natural teeth are almost invariably of a greater sulcus angle.

20. *The Articulator should have Incisal Guidance, adjustable to the Sulcus Angle of the Remaining Natural Teeth.*



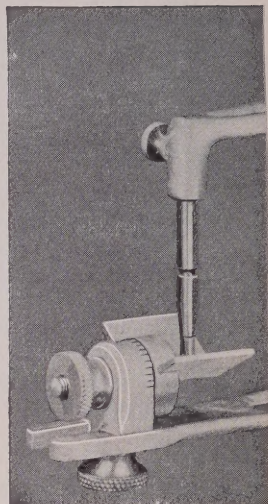
A
Fig. 13 (over).



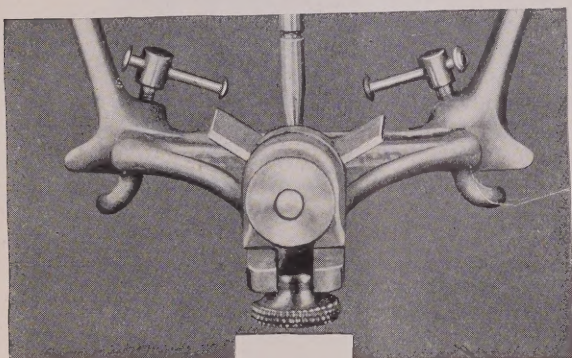
B

C

D



F



E

Fig. 13—The Snow New Century Articulator, with the Wadsworth Incisor Guide Attachment, (A) held to the Articulator by a special adapter, taking the place of the regular or special Lower Model Support. The regular Upper Model Support carries the straight Incisor Rod is used with this as noted.

B shows the Wadsworth Incisor Guide, with adjustable plates, C a close up of the front end of the adapter or the lower model support (used with the Gysi Simplex Articulator), D straight and curved incisor rods (the curved rod is useful with the Face Bow), E and F views of Incisor rod in incisor guide.

Note—That incisor rod should fit into the centre of the trough, as in F, should this not be the case, the upper bow should be adjusted to correct this.

As may be noted in Fig. 13, the regular Snow New Century Articulator, fitted with adapter and Wadsworth Incisor Guide Support, answers this requirement well, having condyle slides, and the incisor guide, both of which are adjusted for the individual patient from check bites, which are taken from the right and left sides of the patient, as subsequently noted (Fig 33).

These check bites are the same as taken for Full Upper and

Lower Cases, and as subsequently noted, the only additional step is that of setting the wings of the Incisors Guide. This is done after the Condyle slides are set for the Inclination of the Condyle Path.

21. *A Simple Gauge for Measuring Sulcus Angles and its Construction.*

In many instances, a small gauge for measuring the Sulcus angle, both of natural teeth in the mouths, and artificial teeth, is useful. This applies on single full lower or full upper restorations, and on all partials in which natural molars and bicuspid remain, or which require artificial molars and bicuspid. As noted in the text, the use of this device is chiefly in measuring the sulcus angle of natural posterior teeth, and obtaining, and grinding, if necessary, the corresponding sulcus angle in the artificial posterior teeth.



Fig. 14—Plan of a Simple Sulcus Angle Gauge, Natural size. So far as the writer knows, this or its equivalent is not now obtainable. A simple method for making one follows in the text.

The construction of a Sulcus guage is a very simple matter, and is as follows:—

1. Procure a piece of Brass or Aluminum about 16 Gauge (B&S) or thereabouts as preferred a little larger than the illustration above.
2. Cut out the illustration above and glue it on the Metal.
3. With a small saw or file shape the metal the same as the drawing.
4. With a small set of steel Numbers, (1/8") stencil in the numbers of the angles. (Steel numbers obtainable at a hardware store, price about \$1.15).
5. Dress down the surface by rubbing, face down, on fine emery cloth.

22. *Mounting Casts in the Articulator with Wadsworth Guide Attachment and with Face Bow, as noted, Fig. 27.*

The Wadsworth attachment includes an Incisor Rod. The technique of mounting is identical with the foregoing, except the Incisor Rod is, as a rule, kept off the Articulator until after both upper and lower models are fastened to the articulator. It is then reinserted for the step of setting the condyle and Incisor inclination, a description of which follows. The curved rod, shown in Fig. 13 D, if used, may remain in position during the process of mounting.

23. A SCHEDULE, UPPER AND LOWER PARTIAL DENTURES, SHOWING THE PRACTICAL USE OF THE SNOW ARTICULATOR AND FACE BOW, WITH WADSWORTH INCISOR GUIDE.

Here follows, in detail, a Schedule of Sitzings and Intervals with an example of a comparatively simple restoration of Upper and Lower Partial Dentures using the system of Articulation described above. The Schedule will be found to be applicable to a large range of Upper and Lower Partial Restorations, and necessary references to the Example chosen (Fig. 15) will be also found opposite each step. All other dental work required is here pre-supposed to be more or less complete. If not, it may be included in the schedule at the convenience of the dentist.

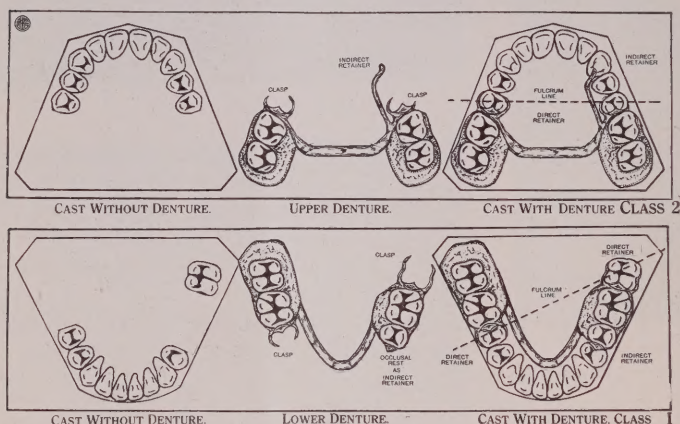


Fig. 15—Design of Proposed Restoration, Upper and Lower, in Plan.

24. First Sitting.

1. Examination, take impression for and make study models, if necessary.
2. Design* (Mental, if evident on inspection:—if not, by Graphic Method, as follows):
 - A. Saddles.
 - B. Parts connecting saddles.
 - C. Retainers and Connectors, (location and choice).
 - D. Occlusal rests (if used).
3. Individual Impressions for:—
 - A. Such Direct Retainers or Occlusal Rests as may be held in place during Main Impression.

*This ground is covered in a previous article in The Journal of the American Dental Association, and Oral Health, September, 1922; The Dental Summary, December, 1922; The Hygeia, January, 1923; also Bulletin No. 5, Canadian Dental Research Foundation, May, 1922.

B. New Inlays and Crowns, etc., which are required to carry Direct Retainers, if required.

C. New Inlays, Crowns for recessed Occlusal Rests, if required.

4. Choice hue, and Mold, of artificial teeth required.

Regarding the Examples—

Steps 1 and 2—This ground is covered in a previous article in Bulletin No. 5, Canadian Dental Research Foundation.

Step 3.—In the examples, this would mean (presupposing wrought clasps throughout) individual impressions of both Upper Bicuspid and the Lower Right 2nd Bicuspid and left Second Molar. If these are to be surveyed and designed from a Surveyor Guide Line, an Upper and Lower Survey impression should be made as described elsewhere.*

Step 4.—As above, choose posterior teeth by measuring the sulcus of natural teeth with Sulcus Gauge, Fig. 14, if necessary.

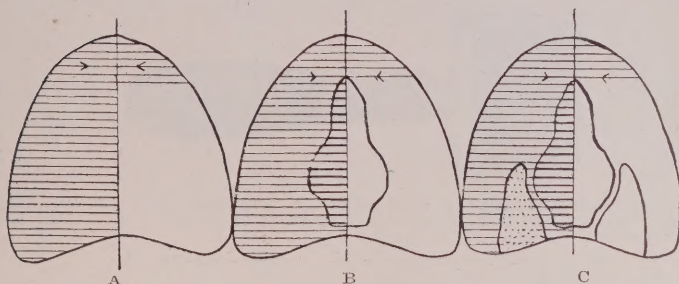


Fig. 16—Examination of mouth for hard and soft areas. A round headed instrument is held lightly in the hand and drawn across the vault as indicated by cross lines, one side at a time, from ridge to median line in vault A. No difference of density is encountered; in Vault B the instrument climbs up a hard central area outlined in centre. In vault C hard area in centre and soft area on either side are detected. With model and pencil near by the outline is sketched on the model as taken from the patient. These areas may be subsequently relieved by thin metal on the model for the hard area, and wax on the impression for the soft areas, if the impression has not sufficiently compressed the latter, or by other means, if preferable, if the saddle covers these. If, on the other hand, the parts which connect the saddles, as the elliptical bar crosses these, the bar may be formed or bent, to accommodate the difference in density.

25. 1st. Interval.

1. Construct such Direct Retainers or Occlusal Rests, Inlays, Crowns, etc., to such a stage that they may be held in place during Main Impression.
2. Secure assortment of teeth, approximate hue and mold.

Regarding the Example—

Step 1. This would include surveying, designing and constructing all four clasps as noted.

Step 2. As above.

*Folder, "Clasp Design and Construction" issued by the Royal College of Dental Surgeons, on application.

26. 2nd. Sitting.

1. Prove hue and mold of teeth already chosen, make selection, lay these aside.
 2. Fit retainers and other parts constructed during interval No. 1 to place in Mouth, prove for interference in Central Occlusion and all other positions. Spot grind until remaining upper and lower teeth interdigitate the same with or without Retainers, if necessary.
 3. Choose and prepare Impression Trays.
 4. Take Main Impressions*, drawing Clasps, Occlusal Rests, etc., already in position. (Note if these parts do not come away in Impression, they may be placed in their prints after its removal.)
 5. Note hard and soft areas on impression, for subsequent compensation in Dentures, Fig. 16.
- Step 1 to 5: as described above.



Fig. 17—A paperhanger's seam roller. A cylindrical seam roller, costing about 75c, is useful in preparing sheet or strips of plasticine for boxing impressions.

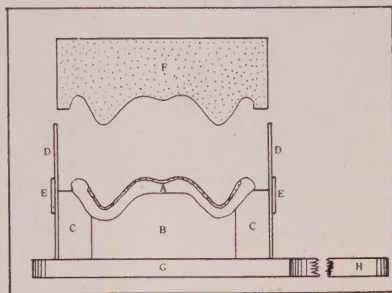


Fig. 18—Diagrammatic illustration of "boxing" an upper impression.

- (a) Impression dipped and coated with collodion or other separating medium.
- (b) Cone of plasticine.
- (c) Strips of plasticine, allowing periphery to project 1-8 inch past.
- (d) Soft metal rolled to 20 gauge.
- (e) Elastic, binding altogether.
- (f) Finished model.

*Note—Many operators prefer to take a single main impression, pouring the cast either with integral or separable retaining teeth (such as teeth to be clasped) rather than the method above described, in which the clasps are completed and in the mouth during the taking of the main impression.

For this single impression method absolute accuracy of every detail about the retaining teeth is essential.

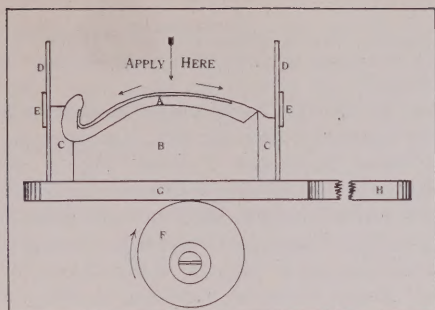


Fig. 19—A Simple Vibrator.

(A, B, C, D, E) Boxed impression, as in Fig. 18.

(F) Stone out of true, or its equivalent.

(G) Wooden Paddle for supporting the whole.

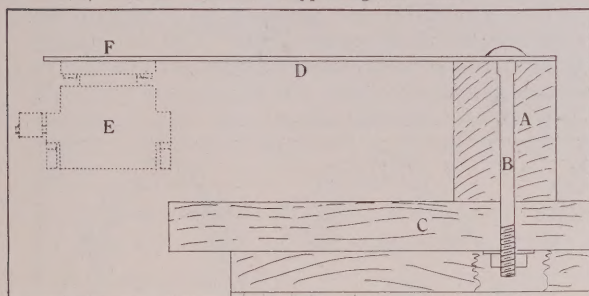
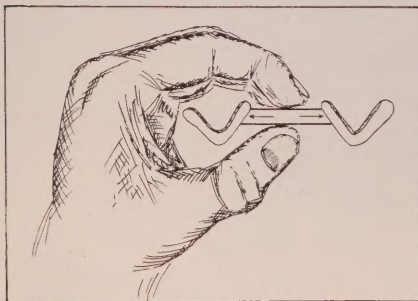


Fig. 20—Electric Vibrator.

A somewhat more elaborate but more efficient apparatus than Fig. 19, readily installed in a laboratory at a cost of approximately \$25.00, might be made from a piece of brass plate $6'' \times 12'' \times \frac{1}{8}''$ (D), bolted to a table (C) firmly attached at one end by means of three ordinary carriage bolts $\frac{3}{8}'' \times 7''$ long (B), on a hardwood block $6'' \times 3'' \times 5''$ (A), and having at its free end bolted a small motor (E) with a flat base, of the Hamilton-Beach or Dumore type, and with a knee switch (G). Upon the shaft is fitted a small eccentric, made from a rod of brass $\frac{7}{8}''$ in diameter and about $\frac{1}{2}''$ in width and with a hole drilled $\frac{1}{8}''$ from the centre. This rapidly revolving eccentric attached to the shaft of the motor, vibrates the whole free end of the plate (F), and the apparatus is useful for impressions, also filling the largest and heaviest flasks with plaster for vulcanization.

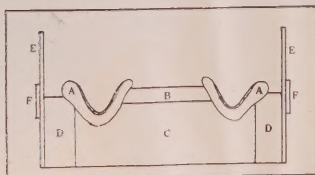


G



A

Fig. 21—Boxing for lower impression (over).



B

The main point of difference between the boxing for lower and upper is the plasticine sheet which

A Is cut to approximate form and expanded by pinching against the side of the lower impression, and is supported first by plaster.

B After which the boxing is completed same as the upper.

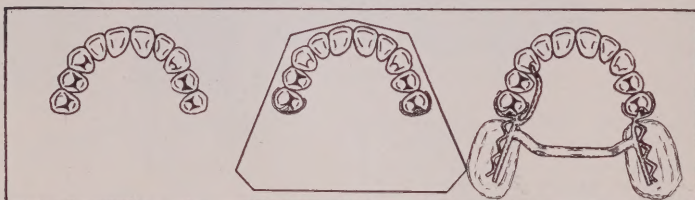
27. Second Interval.

1. Add wax to undercut metal parts; vaseline to Inlays, etc., to facilitate removal from stone cast, if necessary.
2. Box and make Upper cast of stone. Fig. 17, 18, 19, 20.
3. Box and make Lower cast of Stone. Fig. 21.
4. Note and outline on casts, hard and soft areas, on these casts, see Figure 16. Compensate model for these if necessary.
5. Outline saddles, make in wax, shellac base plate, or similar.
6. Construct Metal Assembly according to design already made, *in one integral piece*, and with wire loops properly placed to retain vulcanite. Fig. 22.

Regarding Example,—

Step 1.—This is probably not necessary here, because the clasp will lift off the stone readily. This step applies chiefly to cases with compound retainers attached to crowns, inlays, etc.

Steps 2-3-4-5-6—As described above.



A. CONDITION AS PRESENTED. B. CONDITION BEFORE. C. CAST AFTER. IMPRESSION. D. SKELETON WORK STEP 1.

Fig. 22—(B) Upper Stone Cast, at beginning of Step 6, immediately before metal assembly is begun. Note clasps on models, placed from the impressions themselves, not fitted on afterwards. (C) Metal Assembly on Cast. Note framework over saddle made of wax, shellac base, or similar material. Note that this framework is one integral piece. This lies at the heart of successful articulation in partials, because if the component parts of the assembly are not joined the trial plates (Fig. 24) have not sufficient stability. If hard area occurs in the median suture, form bar to accommodate.

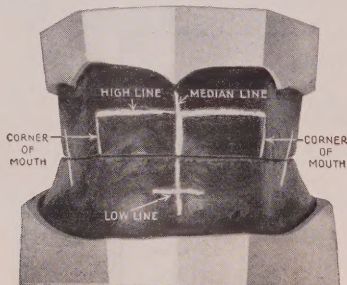


Fig. 23—A full upper and lower trial plate with markings. In partial dentures, these lines are required in proportion the anterior losses to be restored; and many partial dentures, in which no extensive losses are found in the anterior, require no markings.

28. *Third Sitting.*

1. Prove Assembly in Mouth for Interference in Central and Lateral positions. Spot Grind, if necessary, until remaining upper and lower teeth interdigitate the same with or without Assembly (metal framework).
2. Take Occlusal Bite:
 - (a) If sufficient facets remaining in Patient's teeth to reproduce relation between upper and lower, no bite rim is necessary.
 - (b) If insufficient facets, or for any other reason build down trial plate 1 mm. past lip in repose in anterior (if upper anterior losses) and long enough to receive prints of remaining lower teeth. If the upper model is not supported over its entire surface by lower teeth, build up lower trial plate also.

Taking Occlusal Bite:

Have the patient "close," bringing natural contacts together in Central Occlusion (if no natural contacts in position), judge by remaining teeth, the Alveolar Processes, or the External Face. If cone of wax or other expedient to prevent a protrusion, is necessary, use it.

3. Check for uniform contact, if it is deemed necessary.
4. Mark median line, if necessary. Fig. 23.
5. Mark high lip line, if necessary. Fig. 23.
6. Mark angle of mouth, if necessary (rare). Fig. 23.
7. Adjust face bow using (A) stem, if large anterior losses; (B) stem if no large anterior losses.

Regarding Example:

Step 1.—As described.

Step 2 & 3.—If both upper and lower second or third molars were present and in contact with definite facets, no bite rims would be necessary.

As there is a lack of natural tooth contact with facets, the posterior upper trial plate is therefore necessary.

As also there is a lack of opposing contact on the lower left side, a lower trial plate is necessary. See Figure 24. The trial plates are then adjusted in the patient's mouth and noted, Figure 25.

Steps 4-5-6—Not necessary in this case.

Step 7—See Figure 26, which illustrates this.

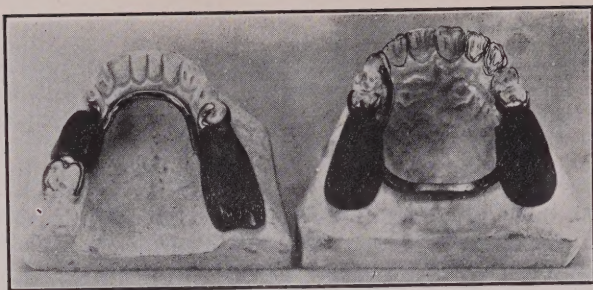


Fig. 24—Wax Bite rims made for example. These are as yet only approximate, not as yet having reached the patient's mouth.

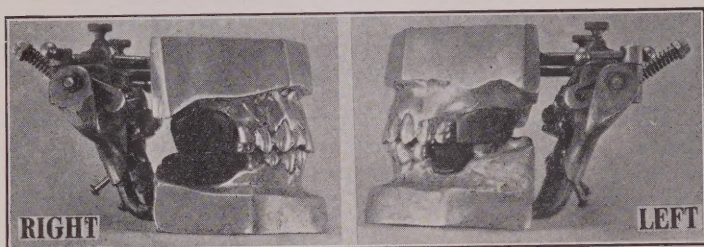


Fig. 25—The Occlusal Bite.

In this case and from now on the Articulator with metal models, as above, is supposed to represent the patient and shows the upper and lower in contact. To effect this, the occlusal surfaces are warmed and the patient instructed to "close". In a case with but few teeth as a guide, the cone of wax or similar may be required to prevent protrusion, as in the case of the full upper and lower restoration.

Note—See "Occlusal" and "Rest" bites. Figs. 38 and 39.



Fig. 26—Face Bow adjusted to patient's upper teeth and trial plate using Stem B or C. For details, see Sections 7 to 16. The articulator, as before, is taken to represent the patient.

29. 3rd. Interval.

1. Remove Incisor Guide Rod. Attach upper model to Articulator, using Face Bow and without tin shoe. Fig. 27, A and B.

2. Remove Face Bow and stem B, if used.
3. Invert, attach lower model in central Occlusion to Articulator using facets, prints on Trial Plates, or both, keeping as near as possible to occlusal plane of teeth. Fig. 27, C and D.

Regarding Example—

Step 1—Described in Figure 27.

Steps 2 & 3—Described in Figure 27.

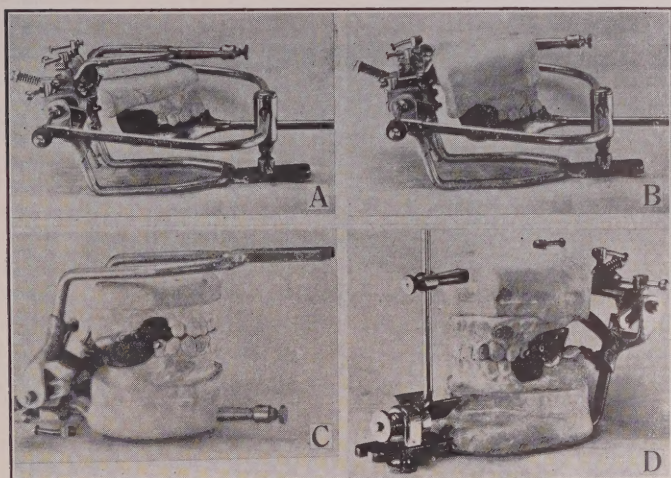


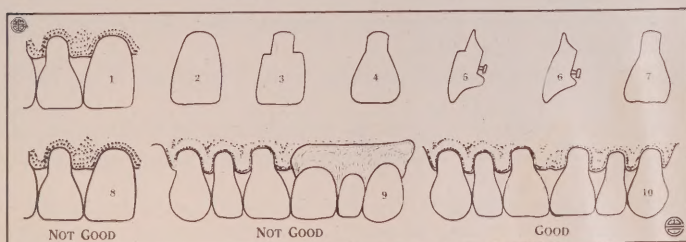
Fig. 27—Luting upper model to Articulator.

A. The upper model and trial plate are just ready to receive the luting plaster. The long lower model support gives the necessary stability to the whole. Note that Incisor Guide Rod is for the time being removed. The Upper Model Support is temporarily held parallel to the bite stem by adjusting screw J Figure 1. The back spring, D is hooked against the body of the Articulator keeping the Articulator condyle equivalents in their furthestmost distal position.

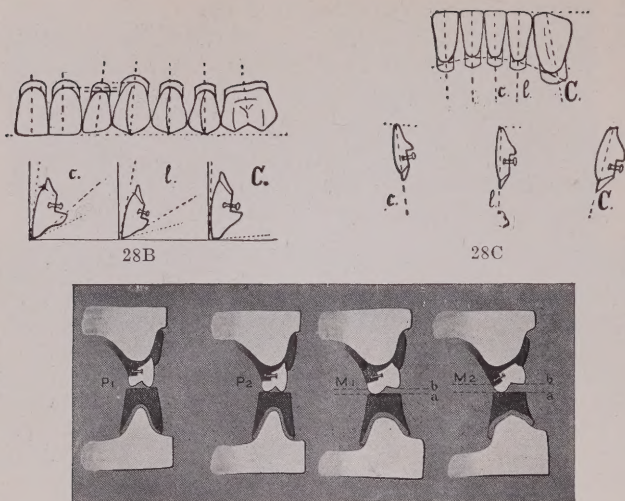
B. (The Upper Model is now luted and the Lower Model is just ready to receive the luting Plaster.)

C. Luting the Lower Model. Note that the incisal guide rod is still absent, and the Face Bow and B Stem are removed, and that the adjusting screw and the back spring (No. J and D) are the same as in A and B.

D. Luting is here complete.



28A (over).



28D

Fig. 28—Arrangement and alteration of teeth.

Anterior Teeth—

Should there be remaining anterior teeth adjacent to the artificial ones, the latter should correspond, both in color and form, to the former. Alteration to stock anterior molds is often necessary to imitate recessed gums, wear or other peculiarities. In 28A is four steps in altering an anterior tooth to show a root. These are as follows:

- 1 and 2. Artificial tooth, correct width, but too long.
3. First cut, outlining the mesial and distal sides of the root.
4. Second cut, outlining the mesial and distal sides of the crown.
5. Third cut, outlining the labial side of the root.
6. Fourth cut, outlining the labial side of the crown.
7. Completed tooth.
- 8, 9 and 10. Examples.

Posterior Teeth—

In 28B and 28C will be noted general plan of arrangement for full dentures after Gysi. This must necessarily be modified, however, to harmonize with individual peculiarities in both form and arrangement. Alterations in color may be made with porcelain stains.

The position of the posterior teeth for securing a balance bite is necessary and possible in direct proportion to posterior losses, and the difficulty increases with the number and malposition of remaining natural teeth. Hence the arrangement 28D after Gysi for full denture work is of more value in cases with the upper and lower anterior six only standing, and similar. Note explanation of balance bite, Fig. 29.

30. 4th. Sitting.

1. Arrange, alter, if required, anterior teeth for esthetics and position. Fig. 28.
2. Alter sulcus angle of posterior teeth, if required. Fig. 30, 31, 32.
3. Make check bites, and set articulator joint slides, and sides of Wadsworth Attachment one side at a time. Figs. 34 and 35.
4. Set posterior teeth for as much Balance contact as possible.
5. Spot grind all teeth for interference in any position, if necessary.
6. Carve wax around remaining teeth. Fig. 36.

The Fourth Sitting is concerned chiefly with the recording or registration of the habitual movements of the jaw, their measurement, and the adjustment of the Articulator in three places corresponding approximately to the three angles of a triangle, which guides it approximately to habitual jaw movements. These three places are as follows in the Snow Articulator as used (1) Right Condyle slide, (2) Left Condyle slide, (3) Wadsworth Incisor Guide. The teeth are also adjusted to balancing contact in the articulator subsequent to the registry of, and its adjustment to, the patient's habitual jaw movements.

It is not considered advisable to review in this pamphlet the preliminaries of Anatomical Articulation. It will be sufficient to note that the right and left check bite, as example shown, Fig. 33, register the position of the jaw in the small right and left excursion movements during normal mastication, during which on the working side, the summits of the upper and lower, buccal and lingual cusps are in contact, Fig. 29-4a. This position in the patient is reproduced on the articulator. Central occlusion is also reproduced on the articulator. Consequently, it is proposed that, in intermediate position, that there are also reproduced, with sufficient accuracy or practical purposes, all the intermediate position on the articulator or also in the patient.

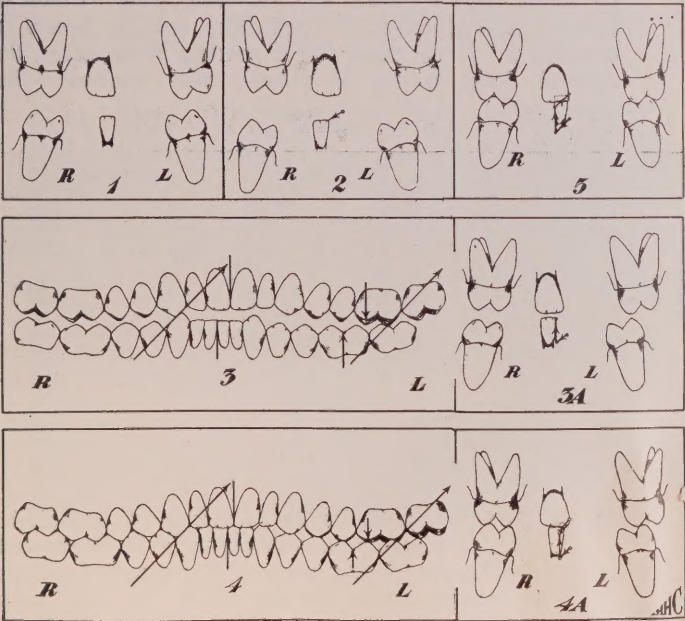


Fig. 29—Diagram of Masticating Movement. (over)

1. Separation of teeth.
2. Lateral movement while separated.
3. Two point balancing contact as recommended by Dr. Rupert Hall for 90 deg. sulcus angle teeth. The jaw is moved to the left, or the balance of contact is between upper and lower right cuspids and left molars. This is most suitable for certain types of Full Denture restoration.
4. Three point contact, as used for teeth at 120 deg. (the usual sulcus angle for artificial teeth).
- 4a. This is approximately the position in the molars at which the right check bite (which indicates the inclination of the left condyle path) is taken.
5. Central occlusion.

It may also be noted that, in the setting of the Articulator, the number of degrees of inclination of the condyle path and that of the Wadsworth attachment, is not learned until after the check bites are taken, and each of these are adjusted from these check bites.

Regarding example:

Step 1. Not indicated here because there are no anterior losses for replacement.

Step 2. The Sulcus gauge, Fig. 14, and might be used on the remaining natural teeth and the artificial teeth altered, if necessary. Should the sulcus angle of the natural teeth approach 120°, the regular molars and bicuspid may best be used. Should, however, the unusual happen, and the sulcus angle of the natural teeth approach 90°, the so-called 90° or deep bite molars and bicuspid might best be chosen. Should the sulcus angle approach 150° or similar flattened form of the occlusal surfaces of the teeth, they may be ground to correspond. In all cases, should grinding be necessary, the occlusal detail should be restored after grinding. See Figs. 31-32.

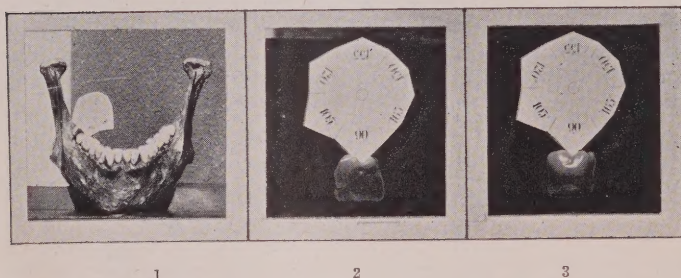


Fig. 30—Use of Sulcus Gauge, Fig. 14.

1. Measuring the sulcus angle of natural teeth.
- 2 and 3. Measuring the sulcus angle of artificial teeth after grinding.

Step 3. The check bites, for the purpose of setting the joint slides of articulator, and subsequently the Wadsworth attachment, are now taken. The patient is instructed to practice moving the jaw to, say the right, as in chewing, so often as it is necessary that the patient can do it with the check bite wax in

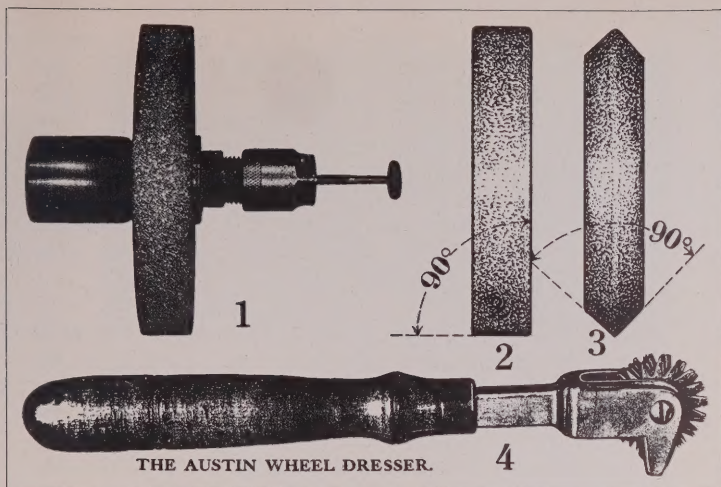


Fig. 31—Materials for grinding.

1. Combination chuck.
- 2 and 3. Formed stones.
- 4 Wheel dresser for forming stone No. 3.

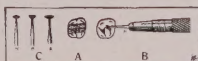


Fig. 32—Restoring Marginal Detail, after grinding sulcus angle.

- (a) Tooth after grinding with such as stone in Fig. 32, No. 3.
- (b) Stones in handpiece.
- (c) Suitable stones for this purpose.

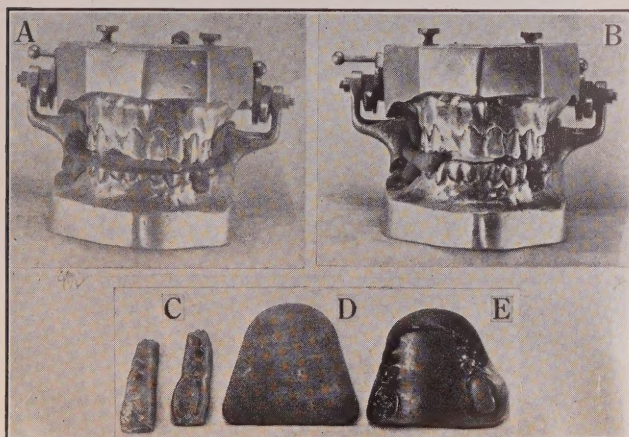


Fig. 33—Right check bites. Note the position of the patient's upper and lower right cusps:—immediately above one another. The right check bite is for the purpose of setting the condyle slide on the opposite (left) of the Articulator. The opposite (left) wing of the Wadsworth Guide is set from the same position, with or without the check bite. The left check bite is taken in a similar manner.

The Articulator with metal models, as before is taken to represent the patient.

position. The anteriors, being in place, the upper and lower right cuspids should be above one another. Any excursive movement of the mandible greater than this is beyond ordinary function. Two little pieces of softened base plate wax are inserted between bicuspid and molars region on each side:—The patient is instructed to reproduce the right movement—the waxes are marked R & L, and removed. Their appearance, immediately before and after removal is as Fig. 33.

Step 4. The two pairs of check bite waxes * are returned to the articulator, one pair at a time. That is: for example, the right pair, meaning those that were taken when the jaw was swung to the patient's right, are returned, and the left condyle inclination set, then the left pair are taken, and the right condyle inclination are set, as in Fig. 34.

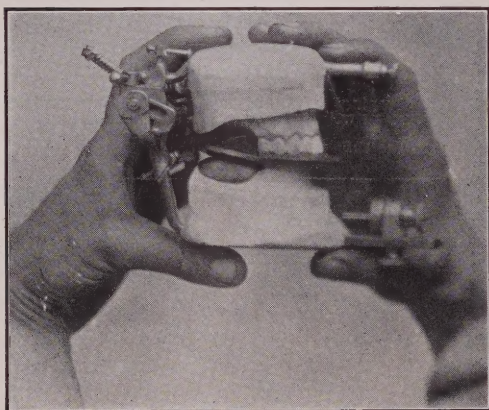


Fig. 34—Setting the Right Side Condyle Slide of the Articulator. The articulator is set, one side at a time, as is the check bite taken one side at a time. This reproduces approximately the travel of the condyles in vertical plane. It is not until this stage that the inclination of the condyle path is known, in this system. The joint slides (Fig. 1 C) are loosened by opening capstan nuts on the top, and the rear spring is also disconnected. The joint slides must move freely. If they do not, press open the slot at C, and also lubricate joint.

The left check bite wax (this shows the Monson check bite wax, Fig. 33, A-D-E) is now put into position and the upper and lower teeth and trial plates on the articulator are gently urged to their place. It will be noted that the right joint slide will fly to a position. If the work is correctly done, this is the correct condyle inclination. Lock it to place by turning the capstan screw. The left side condyle slide of the articulator is then set, in a similar manner, from the right check bite.

*Dr. Monson has suggested a single shaped piece of wax which reduces possible confusion in handling these waxes. These are on the market, bearing his name, and may be noted, Fig. 33, A-D-E.

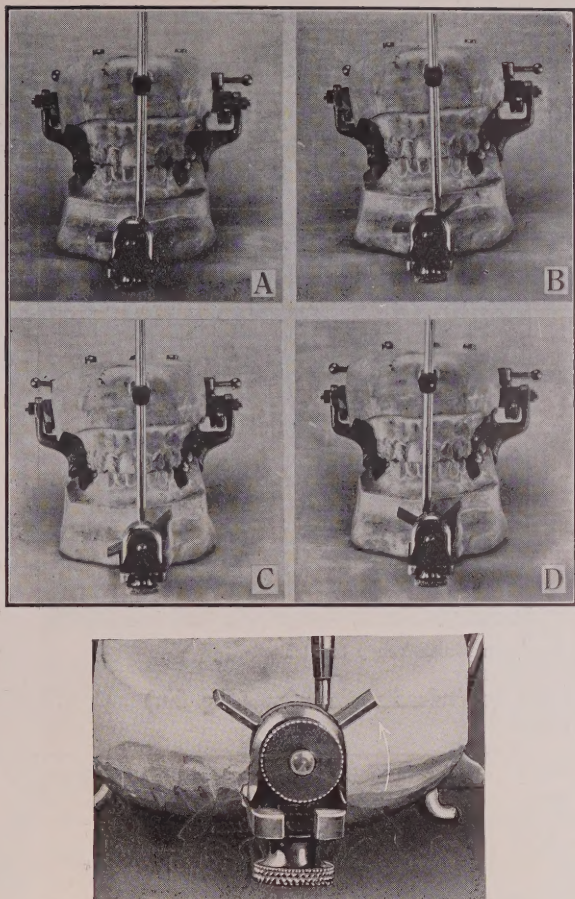


Fig. 35—Setting the Wadsworth Incisor Guide.

This is most conveniently done after the condyle paths are set. The incisor rod is adjusted to fit into the centre of the trough and the lock screw tightened. The central knurled nut is slackened off (A), and the teeth set to say the left side (patient's right side) till the upper and lower right cuspids are above one another. If the anterior teeth do not show on the model, as they do in the above example, set them up temporarily in the porcelain teeth to be used. This gives the lateral position, as in B. The right wing is then moved up till it touches the incisor rod, as in B and E, and is held with a little plasticine, as in C. To adjust the left wing, repeat on the opposite side, as in D.

A. Moving articulator to left side (patient's right side).

B. Bringing up right wing.

C. Fastening right wing with plasticine.

D. Bringing up left wing.

E. Close up of right wing coming up into position.

Note.—In this example the remaining upper and lower teeth in articulation guide the wings of the incisor guide. This guide being absent, the artificial teeth, properly chosen and ground if necessary for sulcus angle, may be set up tentatively, and the guide adjusted from these, or the check bites may be used.

Step 5. The Wadsworth Incisor Guide is now set, either with or without the check bite. Fig. 35.

Step. 6. The remaining teeth are set in position, on the articulator, checking for interference in lateral and incisive movements, both in articulation and in the mouth. After the adjustment, with such grinding as may be necessary, the wax is carved about the teeth. Fig. 36.

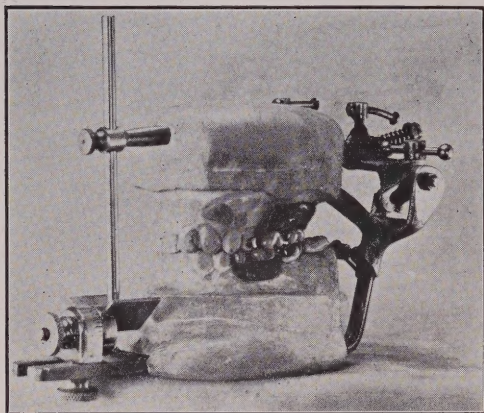
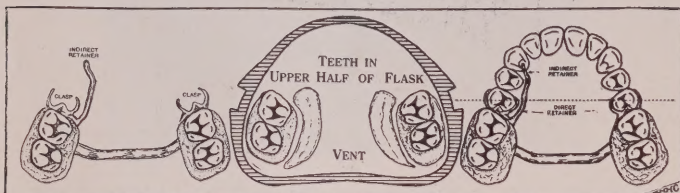


Fig. 36—Teeth Waxed ready to Flask.

31. 4th. Interval.

1. Flask and vulcanize denture. (Fig. 37.)
2. Finish.



E. READY TO FLASK. ALSO H. FINISHED.

F. HALF FLASKED.

G. UPPER DENTURE IN PLACE, CLASS

Fig. 37—Flasking upper case of example.

32. 5th. Sitting.

1. Insert, spot grind before piece snaps home, if necessary.
2. Spot grind on occlusal surface in both central and lateral positions, if necessary.

Regarding the example, this is the installation of the pieces. If the clasps are surveyed, it is not at all probable that spot grinding other than occlusal will be necessary. If vulcanizing and the work between the last try-in have been done without mishap, it is also improbable that occlusal or other spot grinding will be necessary.

33. *Subsequent to Fifth Sitting.*

Regarding example, it is often advisable to see patient at necessary intervals for adjustments or perhaps rebasing until case is considered finished. After that, case now comes into the stage of Maintenance and Repair. If it is deemed wise the patient might be asked to return at stated intervals until the dentist is assured that the case may be considered as completed.

34. *PARTIAL UPPER DENTURE VS. REMAINING NATURAL TEETH.*

Note: (All other work required is presupposed to be complete. If not, it may be included in this schedule at the convenience of the dentist.)

This schedule resembles the foregoing schedule, and here follows:

35. *1st. Sitting.*

1. Examination, take impression for and make study models, if necessary.
2. Design, Upper (Mental, if evident on inspection:—if not, by Graphic Method, as follows):
 - A. Saddle.
 - B. Parts connecting saddles.
 - C. Retainers, (location, cohicce, and design of retainers) and conectors.
 - D. Occlusal rests (if used).
3. Individual Upper Impressions for—
 - (a) Such Direct Retainers or Occlusal Rests as may be held in place during the Main Impression.
 - (b) New Inlays and Crowns, etc., which are required to carry Direct Retainers, if required.
 - (c) New Inlays, Crowns for recessed occlusal rests, if required.
4. Choice of hue, and mold.

36. *1st. Interval.*

1. Construct such Direct Retainers or Occlusal Rests, Inlays, Crowns, etc., to such a stage that they may be held in place during Main Impression.
2. Secure assortment of teeth, approximate hue and mold.

37. *2nd. Sitting.*

1. Prove Hue and Mold of teeth already chosen, make selection.
2. Fit retainers and other parts constructed during interval No. 1 to place in mouth, prove for interference in Central and Lateral positions. Spot grind until remaining upper and lower teeth interdigitate the same without or without Retainers.

3. Choose and prepare Impression Tray.
4. Take Upper Main Impression, drawing Clasps, Occlusal Rests, etc., already in position. (Note if these parts do not come away in Impression, they may be placed in their prints after removal.)
5. Note hard and soft areas on impression. Fig. 16.
6. Make plaster impression half way down lower natural antagonizing teeth. (As suggested, Dr. R. Gordon McLean Toronto.)

38. 2nd. Interval.

1. Add wax to undercut metal parts; vaseline to inlays, etc., to facilitate removal from stone cast.
3. Box and make Upper cast of stone.
4. Box (if thought necessary) and make Lower cast of Fusible Metal.
5. Note and outline on Upper cast hard and soft areas, relieve these.
6. Outline saddles, make in wax or shellac base plate.
7. Construct Metal Assembly (framework) according to designs already made, with wire loops properly placed to retain vulcanite, relieving for hard areas, as before, if necessary.

39. 3rd. Sitting.

1. Prove Assembly in Mouth for Interference in Central and Lateral positions. Spot grind until remaining upper and lower teeth interdigitate the same with or without Assembly.

Take Bite.

- (a) If sufficient facets remaining in Patient's teeth to reproduce relation between upper and lower, no bite rim is necessary.

- (b) If insufficient facets, build down trial plate 1 mm. past lip in repose in anterior, (if upper anterior losses) and long enough to receive prints of lower posteriors (if lower posterior losses).

2. Have patient close, bringing natural contacts together in Central Occlusion (if no natural contacts in position, judge by remaining teeth).

3. Check for uniform contact, if necessary.

4. Mark median line, if necessary.

5. Mark high lip line, if necessary.

6. A $\frac{1}{2}$ inch bow using (A) stem, if large anterior losses.
no large anterior losses.

40. 3rd inter

1. Attach unper model to articulator, using Face Bow.
2. Remove Face P and Stem B, if used.
3. Attach Ant by joining lower model in Central Occlusion to articulator, using facets, prints on Bite Rims, or both, using model support with adapter, similar to Fig. 27.

41. *4th. Sitting.*

1. Arrange and alter anterior teeth, if required.
2. Make check bites, and set articulator joint slides, and slides of Wadsworth Attachment one side at a time, as described.
3. Arrange posterior teeth for as much Balance Contact as possible.
4. Spot grind posterior teeth for interference any position, if necessary.
5. Carve wax around remaining teeth.

42. *4th. Interval.*

1. Flask and vulcanite denture.
2. Finish.

43. *5th. Sitting.*

1. Insert, spot grind before piece snaps home, if necessary.
2. Spot grind on occlusal surface in both central and lateral positions, if necessary.

44. *Subsequent.*

See patient at necessary intervals for adjustments or rebasing until case is considered complete.

45. *PARTIAL LOWER AND NATURAL UPPER.*

The schedule is almost identical with the foregoing schedule of Partial Upper vs. Natural Lower, except that references to upper and lower are reversed.

46. *FULL UPPER DENTURE VS. PARTIAL LOWER DENTURE.*

Note: (All other work required is presupposed to be complete. If not, it may be included in this schedule at the convenience of the dentist.)

A proposed schedule here follows, using the Snow instruments and the Wadsworth Incisor Guide.

47. *First Sitting.*

1. Examination, take impression of Lower Partial for Study Model, if necessary.
2. Upper Impression.
3. Design, Lower (Mental, if evident on inspection:—if not, by Graphic Method, as follows):
 - A. Saddle.
 - B. Parts connecting saddles.
 - C. Retainers, (location, choice, and design of retainers) and connectors.

D. Individual Impressions for Lower:—

- (a) Such Direct Retainers or Occlusal Rests as may be held in place during Main Impression.
- (b) New Inlays and Crowns, etc., which are required to carry Direct Retainers, if required.
- (c) New Inlays, Crowns for recessed occlusal rests, if required.

5. Choice hue, and mold.

48. *First Interval.*

1. Box Impression, and form Upper Cast of Stone.
2. Construct such Direct Retainers or Occlusal Rests, Inlays, Crowns, etc., to such a stage that they may be held in place during Main Impression.
3. Secure assortment of teeth, Approximate hue and mold.

49. *Second Sitting.*

(The Second Sitting concerns the partial Lower only, so that the metal framework may be done in the second interval and the upper and lower Trial plates brought together in the third sitting).

1. Prove Hue and Mold of Teeth already chosen, make selection.
2. Fit retainers and other parts constructed during interval No. 1 to place in Mouth.
3. Choose and prepare Lower Impression Tray.
4. Take Main Lower Impression, drawing Clasps, Occlusal Rests, etc., already in position. (Note:—If these parts do not come away in Impression, they may be placed in their prints after removal.)

50. *Second Interval.*

This deals also only with the lower, for the same reason as stated, Sec. 49.

1. Add wax to undercut metal parts; vaseline to Inlays, etc., to facilitate removal from stone cast.
2. Box, and make lower Cast of Stone.
3. Outline saddles, make in wax or shellac base plate, or similar.
4. Construct Metal Assembly according to designs already made, with wire loops properly placed to retain vulcanite, and allowing for hard and soft areas if necessary.

51. *Thrd Sitting.*

1. Prove Lower Assembly in mouth, make correction if necessary.
2. Hatch Upper Mouth with Ball end Instrument to locate hard and soft areas. Compensate for these on the model, with thin metal, if necessary. Fig. 16.

3. Build soft metal base over the model and over the metal compensation (for hard areas), if present.
4. Build down bite rim of upper trial plate in modelling compound trimming anterior part to 2 mm. past the lip in repose, at right angles to median line of face, and posterior part directly below ridge, about 6 mm., or $\frac{1}{4}$ of an inch wide, and built to the approximate form of the lower teeth—build also cone of wax at distal part of upper trial plate. Complete facial contours.

Ask patient to "close," keeping tongue on cone of wax, if necessary. If the patient has not given a protrusive movement, the REST BITE is now secured. Trim upper bite rim if necessary.

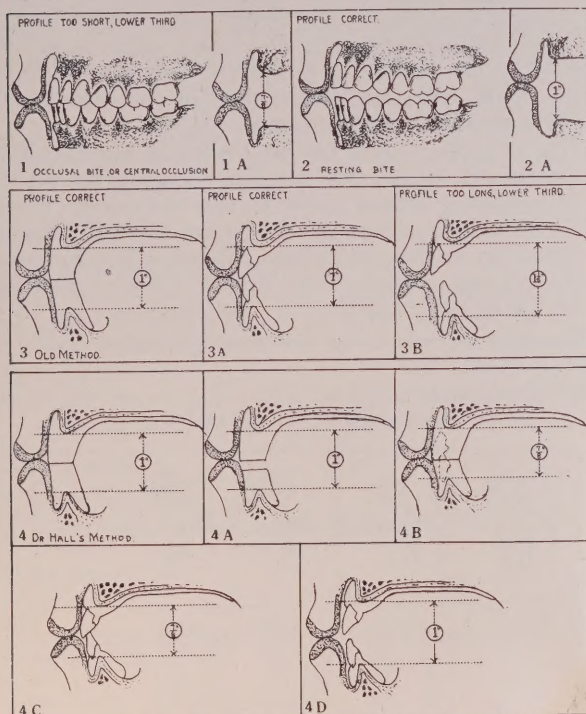


Fig. 38—Occlusal and Rest Bites. See also Fig. 39.

NOTE THAT THIS DRAWING REFERS TO THE FULL UPPER AND LOWER RESTORATION. IN PARTIALS, THE DISTANCES ARE MODIFIED ACCORDING TO THE PRESENCE OF REMAINING TEETH.

1. Indicates teeth in Central Occlusal Bite.
- 1A. Corresponding distance between edentulous jaws.
2. Rest Bite, natural position of teeth and jaws during relaxation, with teeth separated $\frac{1}{2}$ " (approximately).

2A. Corresponding distance between edentulous ridges, in rest bite, approximately 1". Profile here correct.

3. Old method of gauging length of upper and lower trial plates;—upper trimmed two millimetres past lips in repose and to occlusal plane. Lower applied to upper, soft and warm, and patient instructed to "close" till profile correct. Distance about 1".

3A. The finished denture made from trial plates in previous cut (No. 3) with jaws in occlusal bite at 1" separated, and in rest bite at 1" and 1½" separation. In other words, the lower plate ½" too high, lessening its stability, causing strain, discomfort in taking and also in masticating food.

4. Dr. Hall's improved method in which the trial plate, first upper to two millimetres past lips in repose, and second lower to conform to this is done as before, giving 1" separation as in old method. Figures 3, 3A, and 3B.

4A. At this stage Dr. Hall recommends cutting off ¼" from the trial plate as noted in the text, and

4B. After having cut incision in the bite rim, and re-heating, bring trial plates together in the proper relation for occlusal bite (¾") and the setting of the teeth is completed and the pieces finished.

4C. Finished Dentures showing correct (¾") separation in occlusal bite, and

4D. Finished Dentures showing correct (1") separation in rest bite. Note diminished height of lower, increasing stability and comfort.

CAUTION—Do not shorten the lower to such an extent that the condyle tips back and interferes with the auditory meatus and causes deafness. Check this by inserting tips of fourth fingers in patients' Auditory meatus. Many cases of deafness have been caused primarily by too short a distance between the maxillae, also have been improved and frequently cured by opening the bite and increasing these distances. See articles in literature by Monson, Wright, and others.

5. Build up bite rims on lower skeleton to fit upper, and, while still warm, have the patient "close" in like manner. Trim lower bite rim if necessary.

6. Trim off posterior upper bite rim 1 mm., the lingual half of the anterior rim opposite the six interior teeth 1 mm., test for occlusal bite. Should patient be able to bring lips in repose, similar to rest position, this is sufficient, if not, trim upper further up to three millimeters. Resoften and have patient "close" with tongue on cone of wax. **OCCLUSAL BITE IS NOW SECURED.**

7. Check for uniform contact with cement or light spatula.

8. Mark median line.

9. Mark high lip line.

10. Adjust face bow, stem A, for transfer to articulator.

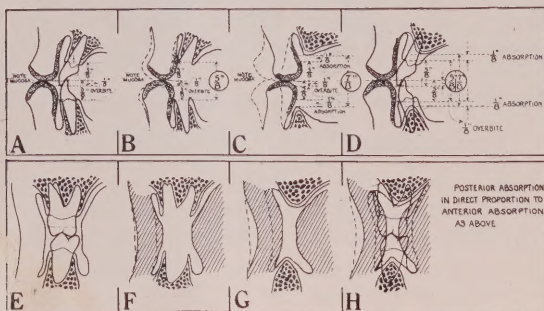


Fig. 39—Absorption and Proportions. NOTE THAT THIS DRAWING ALSO REFERS TO THE FULL UPPER AND LOWER RESTORATION. IN PARTIALS THE DISTANCES ARE MODIFIED ACCORDING TO THE PRESENCE OF REMAINING TEETH. THE AMOUNT OF ABSORPTION IS ALSO MODIFIED BY THE PRESENCE OF REMAINING ADJACENT TEETH. The distances proposed in the preceding figure are based on the proposed distances below.

Presupposing, in terms of inches, the crown of the upper and lower teeth to be approximately three-eighths of an inch (Black's average measurements indicate a trifle above for the upper central incisor, and a trifle below for the lower central incisor for the average individual), this chart indicates the approximate loss of tissue through absorption on the supposition of the loss of tissue as one-third of the length of the original crown.

(a) Upper and lower teeth in position. Note $\frac{3}{8}$ " length of the crown with $\frac{1}{8}$ " overbite.

(b) Immediately after extraction. Lips lose some support.

(c) Nine months to one year after extraction. Absorption, which is supposed to be one-third the length of the original crown in full cases, less in partials because of the presence of remaining adjacent natural teeth, has here taken place,—this is noted as one-eighth of an inch. Upper chiefly at the expense of the buccal and labial plate, lower at the expense of buccal, labial, and lingual $\frac{7}{8}$ " relation of absorbed ridges during OCCLUSAL BITE.

Note position of lips from lack of support of teeth, plus $\frac{1}{8}$ " during REST BITE as noted in previous figure.

(d) Indicating the original teeth, (in phantom) absorption, with approximate proportions.

(e, f, g, h) Proportions in Molar Region. (Note similarity.)

52. *Third Interval.*

1. Attach upper model with trial plate to articulator with Face Bow in place.
2. Attach lower model in articulator with Lower trial plate guided by prints in occlusal surface of upper trial plate, using special lower model support, Fig. 27.
3. Set approximately anterior teeth, upper and lower.

53. *Fourth Sitting.*

1. Rearrange anterior teeth if necessary.
2. Make check bites, and set articulator joint slides, and the planes of the Wadsworth guide, one side at a time.
3. Place remaining teeth for as much balancing contact as is possible.
4. Approximately carve wax around remaining teeth, and try in mouth at any stage desired in this sitting.

54. *Fourth Interval.*

1. Complete wax carving.
2. Vulcanize and finish both dentures.

55. *Fifth Sitting.*

Insert upper and lower correct occlusion by spot grinding, from carbon paper, if necessary. Allow patient to wear for two or three days.

56. *Sixth Sitting and Subsequent.*

1. Using stem B. Remount upper Denture (previously oiled for removal) on articulator. Remove stem B and then remount lower with check bite in central occlusion. Spot grind if necessary with carbon paper. Keep patient under observation till soreness or other difficulty or necessity for rebasing, until the case is considered complete.

The Canadian Dental Research Foundation

is the official Research Organization of the Dental Profession in the Dominion of Canada, two Directors being appointed by the Dental Board of each Province, and two Directors appointed, ex-officio, by virtue of their office in the Canadian Dental Association.

All Subscriptions are forwarded by the Secretary to the National Trust Company, Trustees for the Canadian Dental Research Foundation, the interest only being used in support of research work in the several Dental Colleges of Canada.

This Bulletin is the ninth of a series of Bulletins to be issued by the Foundation. Complimentary copies of all Bulletins issued will be sent to Canadian Dental Practitioners.

Any Dentist in Canada who feels that he has any original work worthy of publication is requested to forward it to the Foundation.

A List of Bulletins Published by the Foundation

- No. 1—The Evolution of the Pus Pocket, May, 1921, H. K. Box. (31 pages, 27 Illustrations).
- No. 2—The Rupert Hall Method for Entire Upper and Lower Dentures, July, 1921, W. E. Cummer. (50 pages, 38 Illustrations).
- Nos. 3 and 4—The Dentinal-Cemental Junction; Histological and Histo-Pathological Studies of the Dental Pulp, May, 1922, H. K. Box. (60 pages, 82 Illustrations).
- No. 5—The Science and Practice of Partial Denture Service, with Special Reference to a Graphic Method of Design, May, 1922, W. E. Cummer. (27 pages, 16 Illustrations).
- No. 6—Combinations as an Aid in the Discovery of Fundamentals in Dentistry and other Sciences, May, 1923, W. E. Cummer, G. R. Anderson, Robert J. Reade. (71 pages, 120 Illustrations).
- No. 7—Studies in Peridontal Pathology; The Mechanics of Occlusion, Summary of the Signs of Incipient Peridontal Disease (Issued in Conjunction with the Department of Health, Province of Ontario), May, 1924, H. K. Box, G. R. Anderson. (120 pages, 135 Illustrations).
- No. 8—Articulation for Partial Dentures with the Snow Apparatus and Wadsworth Incisor Guide, June, 1924, W. E. Cummer, I. H. Ante, J. A. Bothwell. (45 pages, 39 illustrations).

Copies of these Bulletins may be obtained from The Secretary, Canadian Dental Research Foundation, 240 College Street, Toronto, Canada.

1 chart (lower) on cover

Combinations which occur Between the Upper and Lower Six Posterior Natural Teeth in Occlusion

A further study, supplemental to Bulletin No. 6, C. D. R. F., "Combinations
as an aid in the Discovery of Fundamentals in Dentistry and other Sciences."

W. E. CUMMER, D.D.S.

REVISED BY

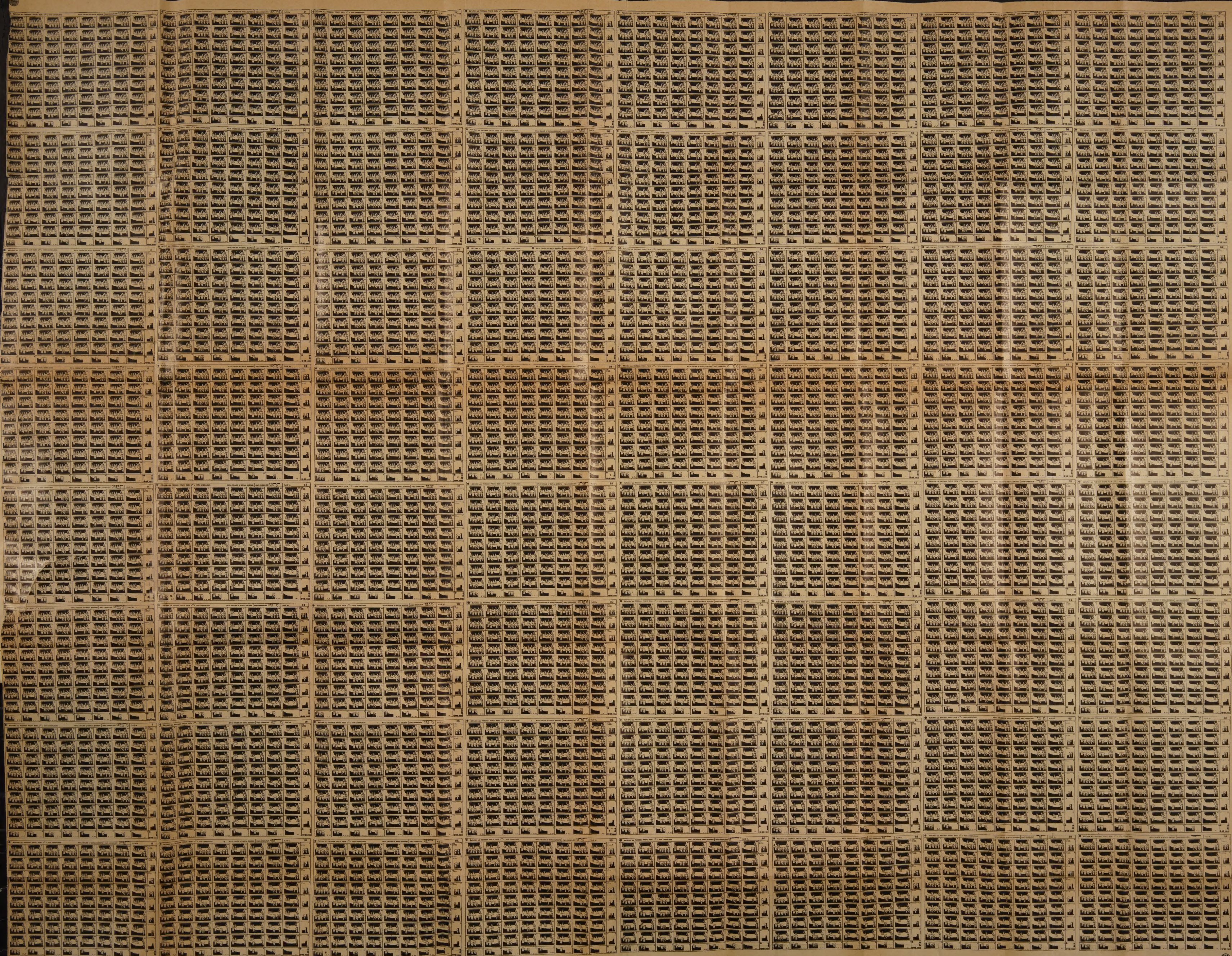
PROF. G. R. ANDERSON and ROBT. J. READE,
M.A., M.D., D.D.S., Toronto

BULLETIN No. NINE



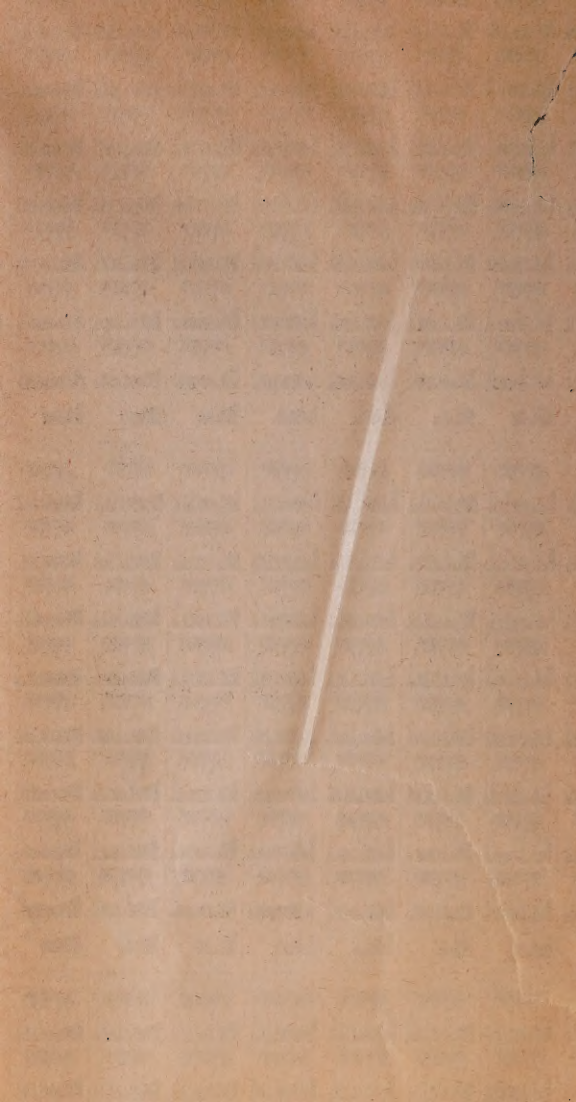
Issued by

The Canadian Dental Research Foundation
June, 1924



THE UPPER AND LOWER POSTERIOR RIGHT TWELVE TEETH IN OCCLUSION
WITH INCISORS CONSTANT TO COMPLETE THE PICTURE. THERE ARE 4,096 COMBINATIONS SHOWN IN ELEVATION
The index will be found in the text, by which any combination may be found, also a device (a circle) for viewing 65536 combinations,
upper and lower, right side

To show the combinations of the upper and lower right sixteen teeth (2^{16}) without the device of the circle,
15 more charts, similar to the above, would be required.
To show the combinations of the upper and lower, right and left, thirty-two teeth (2^{32}), 1,048,575 more
charts, similar to the above, would be required.



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6. Method of Development of the Sixty-four Combinations of the Lower Teeth.
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8. Series of the Upper and Lower Teeth in Occlusion, Shown in Elevation.
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Combinations which Occur Between the Upper and Lower Six Posterior Natural Teeth in Occlusion

A further study, supplemental to Bulletin No. 6,* Canadian Dental Research Foundation, "Combinations as an Aid in the Discovery of Fundamentals in Dentistry, and other Sciences."

W. E. CUMMER.

Revised by

Prof. G. R. Anderson and Robert J. Reade, M.A., M.D., D.D.S.
Toronto, Canada.**

1.—*Standardization in Dentistry.*

The importance, and practical utility, of Standardization in fields of endeavor, similar to that of Dentistry, is unquestioned. It is to a large extent, due to Standardization, that such necessities as are produced by printing and the allied arts and crafts, are within the reach of all the people; and it is also due to standardization, that such a widely used convenience as the present motor car is available to so many. Also many other advantages due to standardization will suggest themselves to the reader.

The word Standardization, as used in this article, means the correlation of a mass of unsystematized knowledge derived from experience, both positive and negative. These facts can, by Standardization, in many cases, be compressed into simple working formulae, more or less uniform in character.

In the field of manufacturing, standardization has resulted in the production of larger quantities of at least equal quality, and by workmen less skilled, and at prices which are not prohibitive to the community in general.

*This Bulletin may be obtained by writing the Secretary, Canadian Dental Research Foundation, 240 College Street, Toronto, Canada.

**The writer is also indebted to Dr. Albert E. Webster, and Dr. J. W. Ingram, who furnished the original drawings of the teeth in the alveolus, and in occlusion; and likewise to Mr. W. V. Byrne and others, for their assistance in preparing this material.

Standardization in Dentistry is capable of great development, more especially on its Prosthetic side, dealing, as it does, with mechanical appliances for lost teeth. This mechanical procedure, following such diagnosis and treatment as may be necessary, may best be handled in the sequence adopted by the trained engineer, namely: Design, Construction, Installation, Maintenance and Repair. This Standardization tends to produce results beneficial to the patient, as better restorative work, available for a large number of patients, and at less cost—and advantageous for the dentist and his assistants in increased financial returns in exchange for their services.

2. Practical Value of this Series in Standardization.

Before Standardization can be fully applied in Prosthetic Dentistry, a large amount of research work still remains to be done. This work is similar in principle to Engineering research, but differs from it, in that Prosthetic restorations are operated in conjunction with living tissues.

Therefore, upon Dentistry falls the onus of an unusual degree of research work for standardization. The series of combinations which follow are submitted with the hope that they may prove useful to the more imaginative, and investigative type of mind in the Dental profession, as well as for the Research worker in general, in the manner described in sections 3 and 4.

3.—Development of Standardized Practice in Partial Denture Service.

Partial Dentures and Bridgework, branches of Prosthetic Dental Service, supply missing teeth in mouths in which a greater or lesser number of natural teeth remain. These natural teeth, and their associate tissues, either singly or together, are utilized for retention, or support, or both.

No Standardized procedure, or formula, is of either practical, or scientific value, unless its application is proven in a large number of cases. The number of combinations of natural teeth, and intervening spaces, is so great that no dentist, no matter how large his experience may be, can hope to see more than a part of these cases. It will be found that many of these cases are practically duplicated.

The keynote of these articles is, that the series of all of the possible combinations given enables the dentist or research worker, who has only a comparatively few of the combinations come under his notice, to prove, or to establish formulae, applicable to all related cases.

Consequently, the preceding series,* and the present series, must be of practical value in the establishment of standard methods of practice. The special purpose the writer has in developing these

*Bulletin No. 6, Canadian Dental Research Foundation.

tables is an aid in the solution of the loading problem, which is the proper use of teeth and gums in carrying additional loads of mastication without injury. It is also an endeavor to standardize methods of "taking the bite."

4.—*It is Hoped that Research Work will Develop the Use of this Series.*

Regarding this subject, Harold K. Box, D.D.S., Ph.D., of the Royal College of Dental Surgeons, Toronto, proposes the following—

"The Series shown in the large sheet attached to this Bulletin, forms an effective demonstration of the magnitude of the dental problem, namely, first, preserving the health of the remaining teeth and their supporting structures, and second, replacing the lost teeth without detriment to the remaining teeth.

The plan of the writer is evident in this, as well as in a similar publication,* and means just this; better dental service for the public, by developing for the dentist, standardized or simplified methods of practice. This is accomplished, in both articles, by presenting to the dentist or dental research worker, not only diagrams, which simplify mental processes in research, but also actual diagrams of various combinations of teeth, which supplement his records with pictures which suggest a vast number of conditions. And a research worker, in order to develop methods which are truly scientific, must have the widest possible experience or knowledge attainable of the particular subject to which he may apply his hypotheses, in order to establish their scientific truth, or fallacy, as the case may be.

The keynote of the text of the series, is that of Standardization through Dental Research, both of Diagnosis, and also of Treatment, whether mechanical or otherwise.

Standardization means, in essence, simplification; and in the neighboring field of Engineering has been carried to a high degree of development. Dealing, as engineers do, with structures built of inanimate materials, which are static, such as a railroad bridge; or dynamic, as a machine, it is somewhat difficult at first to trace the connection between standardization in this, and in the dental field.

The fact is, that in some of the fields within dentistry, standardization has already resulted in orderly mental and technical procedures, growing out of previous empiricism. Black's standardized method of cavity preparation is but one outstanding example of standardization.

Regarding its use in the study of traumatic occlusion, this series is valuable, because it shows the remaining teeth immediately after the loss of the adjacent teeth before they leave their natural positions. This is a distinct advantage in study. It is, of course, well known

*Bulletin No. 6, Canadian Dental Research Foundation.

that, immediately upon the loss, of even a single tooth, latent forces become operative, which not only tend to, but frequently do, produce that successive change in occlusal relation, commonly known as traumatic occlusion.

It is, moreover, the firm belief of the writer, that the next great step in Preventive Dentistry will come from a correlation of research in the fields of Partial Restorations, and Peridontal Disease."

It is the hope of the writer of this bulletin (and a similar bulletin which preceded it*), that investigators in other fields of dentistry will find in these bulletins material which will assist them in a similar manner.

5.—*Method of Development of the Sixty-four Combinations of the Upper Teeth.*

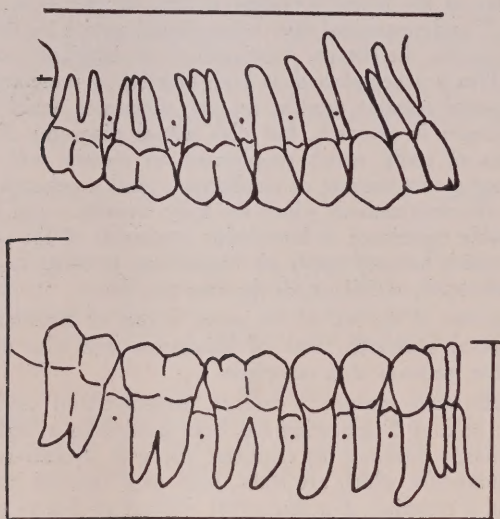


Fig. 1.—Charts of Upper and Lower Teeth, in the alveolus, provided by Dr. J. W. Ingram, Professor of Dental Anatomy, Royal College of Dental Surgeons, Toronto. These Charts are furnished with guide lines referred to later, which ensure the correct position in occlusion, in the construction of the charts.

From the Charts of the natural teeth, (Fig. 1) and beginning with the upper teeth, a chart of all the combinations of the posterior six upper natural teeth was made from the Master Chart 2^c, which is reproduced in Fig. 2.

The method is that of substitution and the letter A is substituted for the third molar, the letters B and C for the second and first molar,

*"Combinations as an Aid in the Discovery of Fundamentals", Bulletin No. 6, Canadian Research Foundation.

the letters D and E for the second and first bicuspid respectively, and the letter F for the cuspid.

Thus, in the development of the sixty-four Combinations of the Upper Teeth, Combination No. 1 appears in the Master Chart 2⁶, Fig. 2, as A B C D E F. The teeth corresponding to these letters

MASTER CHART OF 2 ⁶ COMBINATIONS = 64 COMBINATIONS										ROYAL COLLEGE OF DENTAL SURGEONS				GROUP																					
														SIXES	Section 6 B																				
1	A	B	C	*	D	E	F			9	A	B	*	D	E	F	17	B	C	*	D	E	F	25	A	C	*	D	E	F	FIVES	Section 5 B			
2	A	B	C	*	D	E				10	A	B	*	D	E			18	B	C	*	D	E			26	A	C	*	D	E				
3	A	B	C	*		E	F			11	A	B	*		E	F		19	B	C	*		E	F		27	A	C	*		E	F	FOURS	Section 4 B	
4	A	B	C	*	D		F			12	A	B	*	D		F		20	B	C	*	D		F		28	A	C	*	D		F			
5	A	B	C	*	D					13	A	B	*	D				21	B	C	*	D				29	A	C	*	D					
6	A	B	C	*		E				14	A	B	*		E			22	B	C	*		E			30	A	C	*		E			THREES	Section 3 B
7	A	B	C	*		F				15	A	B	*		F			23	B	C	*		F			31	A	C	*		F				
8	A	B	C	*						16	A	B	*					24	B	C	*					32	A	C	*					TWOES	Section 2 B
																														FOURS		Section 4 A			
33	A	*	D	E	F					41	B	*	D	E	F			49	C	*	D	E	F			57	*	D	E	F			THREES	Section 3 A	
34	A	*	D	E						42	B	*	D	E				50	C	*	D	E				58	*	D	E						
35	A	*		E	F					43	B	*		E	F			51	C	*		E	F			59	*		E	F			TWOES	Section 2 A	
36	A	*	D		F					44	B	*	D		F			52	C	*	D		F			60	*	D		F					
37	A	*	D							45	B	*	D					53	C	*	D					61	*	D							
38	A	*		E						46	B	*		E				54	C	*		E				62	*		E				ONES	Section 1 A	
39	A	*			F					47	B	*			F			55	C	*			F			63	*			F					
40	A	*								48	B	*						56	C	*						64	*							NONES	Section 0 A
																														TOTAL COMBINATIONS		64			

Fig. 2.—Master Chart 2⁶.

As previously described*, all of the combinations of six objects are included in this chart, under the symbols A B C D E F. In developing the combinations of the six upper and lower teeth, the teeth are merely substituted for the letters, as described in the text.



Fig. 3.—Combinations of the Upper Posterior Right Six Teeth, made from the Master Chart 2⁶, Fig. 2. These were made by pasting, in ruled squares numbered, printed duplicates of the upper teeth, Fig. 1, from which the teeth not needed were removed by the shears. The above, in which the incisors appear only to complete the picture, shows the result considerably reduced in size. These are later printed on gum paper for use in developing the series, as described in the text.

*Bulletin No. 6, Canadian Dental Research Foundation. This Bulletin shows the method by which combinations of any six objects, causes, circumstances, or any similar items may be read off the Master Chart in a like manner. It also shows Master Charts suitable for one, two, three, four, five, six, seven, and eight items, with examples.

appear in Fig. 3, Combination No. 1, as 3rd, 2nd and 1st Molars, 2nd and 1st Bicuspids, and Cuspids. The incisors appear only to complete the picture.

Again, in the development of the sixty-four Combinations of the Upper Teeth, Combination No. 2 appears in the Master Chart 2⁶, Fig. 2, as A B C D E. The teeth corresponding to these letters appear in Fig. 3, Combination No. 2, as 3rd, 2nd and 1st Molars, 2nd and 1st Bicuspids. The Incisors appear, only to complete the picture.

Once more, in the development of the sixty-four Combinations of the Upper Teeth, Combination No. 3 appears in the Master Chart 2⁶, Fig. 2, as A B C E F. The teeth corresponding to these letters appear in Fig. 3, Combination No. 3, as 3rd, 2nd and 1st Molars, 1st Bicuspid and Cuspid. The Incisors appear, only to complete the picture.

In like manner the remaining combinations, Nos. 4 to 64, as they appear in Fig. 2, Master Chart 2⁶, are substituted for teeth in a similar way and appear as combinations Nos. 4 to 64 in Fig. 3.

6.—Method of Development of the Sixty-four Combinations of the Lower Teeth.



Fig. 4.—Combinations of the Lower Posterior Right Six Teeth, similar to the Upper shown in Fig. 3. The incisors appear only to complete the picture. These are later printed on Bristol Board for use in developing the series, as described in the text.

The development of the combinations of the lower posterior six teeth, is identical with that used for the upper. The horizontal guide

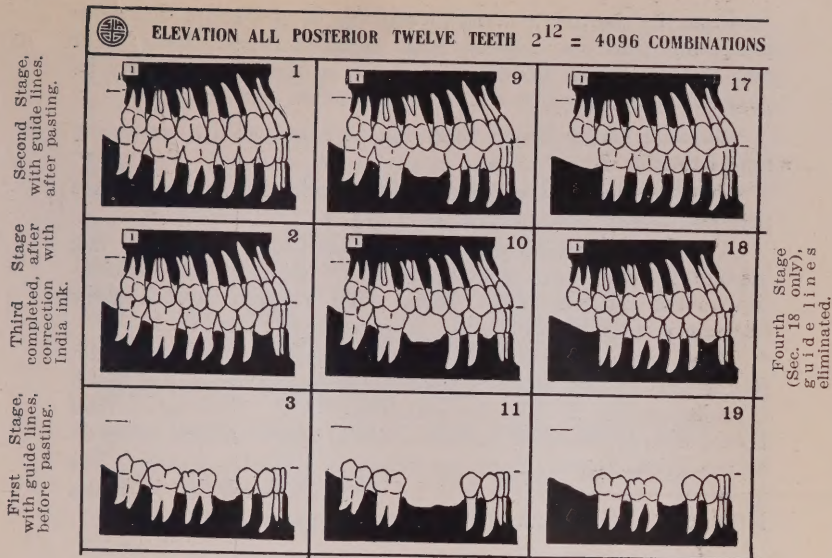


Fig. 5.—Building the 4096 Combinations of the Upper and Lower Teeth.

This figure, No. 5, shows a section of Chart No. 3 of the upper teeth, that is, the section marked 1 applied to sections of the chart of the lower teeth, Fig. 4, namely, the sections marked 1, 9, 17, and 2, 10 and 18.*

lines noted in Figs. 1, 3, 4 and 5, are for the purpose of maintaining a uniform relationship and alignment between the upper and lower teeth while adjusting and pasting, as described below.

7.—Method of Development of 4096 Combinations of Both the Upper and Lower Teeth in Occlusion.

The following is a description of the method of the development of 4096 combinations of both upper and lower teeth in occlusion.

From the chart of the *upper teeth*, Fig. 3, upwards of 64 prints were made** on *Gum Paper*. These sixty-four prints were placed in position, one upon the other, and cut into sixty-four sections along the lines. This results in sixty-four bundles. Each bundle contains sixty-four prints, or labels, of one upper combination. That is to say, one bundle contains sixty-four prints of combination No. 1, a second bundle contains sixty-four prints of combination No. 2, and so on.

*In pasting the upper teeth on the lower in sections 1, 9 and 17, it will be noted that a small margin of paper overlaps the lower teeth. In sections 2-10 and 18, this overlapping is corrected with pen and India ink. Also in section 18, the guide lines are eliminated. Sections 3, 11, and 19 show the lower teeth before the application of the upper.

**To make sixty-four prints from charts Figs. 3 and 4, it was necessary to have zinc etchings made from the original, to which the index is added. These zinc etchings, in the printing press, produced both the prints on Gum Paper and Bristol Board.

From the chart of the *lower teeth*, Fig. 4, upwards of sixty-four prints were made on sixty-four large pieces of *Bristol Board*. But note that the Bristol Boards are not cut, so that, on them may be pasted the different prints of Gum Paper before mentioned.

On each Bristol Board chart will be found sections numbering from 1 to 64.

For the purpose of obtaining 4096 combinations, we now have sixty-four Bristol Board charts, as in Fig. 4.

Let us now consider one Bristol Board Chart. Take our first bundle of Gum Paper, which contains 64 prints of one combination, that is combination No. 1, and paste one print on each of the 64 sections of the Bristol Board. Thus we have Plate No. 1.

Then take another Bristol Board Chart, and on each of its sixty-four sections paste a label of the second bundle of Gum Paper, that is Combination No. 2. Thus we have Plate No. 2. Then take a third Bristol Board Chart and perform a similar operation, and so on till all the Bristol Board Charts are treated in a similar manner. We now have sixty-four Bristol Board Charts completed, that is, Plates No. 1 to 64, which show 4096 different combinations.

8.—*Series of the Upper and Lower Teeth in Occlusion, Shown in Elevation.*

Attached to the back cover page of this booklet will be found a large folded sheet upon which is printed the sixty-four charts. Each chart shows sixty-four combinations of the upper and lower right posterior twelve teeth in occlusion. As already noted, the incisors, both upper and lower, recur in each combination, but only to complete the picture.

In the upper right hand corner of each chart will be found its serial number. Also upon each chart there is an index for the sixty-four combinations contained within it. This index is found in the right vertical column, and in the lower horizontal column. The use of these serial numbers and index will be considered in Sec. No. 9.

The foregoing charts do not consider the cases in which the incisors vary. Fifteen more charts would be required, to show all the combinations on the right side (65,536) in which the incisors would vary. In order to obviate the necessity for making these fifteen charts, a method is provided for viewing them by means of the use of a circle, which is described in Sec. 10.

A brief study of this folder will reveal similarities running through the different plates like a pattern in lace.

It is hoped that the similarities here found will assist the research worker to present to the practicing dentist a standardization of work, whether this work refers to mental or digital technic.

The various plates on this folder will suggest to physicians, nurses, laboratory technicians, and patients, and all those who are interested in better dental health, the magnitude of the dental problems which confront them.

The combinations are printed on one large sheet suitable for framing.* This is for the purpose of enabling the investigator to more easily and readily compare the different conditions that may present.

9.—The Index for this Series and its Use.



Fig. 6.—The Plate Index for 2^{12} Combinations. The use of this Index is described in the text. Note that this Index shows the combinations of the UPPER posterior six teeth, and is only for the purpose of finding the PLATE containing the desired combination. It will be noted that the above Plate Index is only the Combinations of the Upper Posterior Right Six Teeth, as seen in Fig. 3, to which has been added an Upper Horizontal Index column, and Right Vertical Index Column, as marked by two arrows. Within the Vertical column, the upper and lower incisors are shown in black, only to complete the picture.

An Index has been provided for the 2^{12} combinations, by which any of the 4096 combinations may be readily obtained. The method is, first to divide the case described into four groups: (1) Upper anterior group, (2) Upper posterior group, (3) Lower anterior group, (4) Lower posterior group, as noted Fig. 7A. It will also be noted that these groups are split apart in this illustration for the sake of clearness. The *upper* anterior and posterior groups serve as an Index for locating the proper *Plate*. The *lower* anterior and posterior groups locate the *combination on this Plate*. The anterior four teeth are sketched in merely to complete the picture, and are not considered in the index.

Referring to the example in Fig. 7B, it is found that, in the *upper* anterior group, no teeth are present, while in the upper posterior group, the third molar is present. Referring to the Plate Index

*A suitable frame for this chart may be secured from Five Dollars up.

(Fig. 6) for Plate Number, the teeth of the upper anterior group will be found along the right vertical column, marked with a vertical arrow; while the teeth of the upper posterior group will be found in the upper horizontal column marked with a horizontal arrow. Searching along the vertical column, the nines are located in the lowest space in the vertical column and the right index finger placed thereon. Searching along the upper horizontal column, the upper third molar is located in the fifth space from the left, and the left index finger is placed thereon. The fingers are caused to move together at right angles, and they will meet on square No. 40, which is the Plate Number required. This Plate 40 is then found.

Again referring to example Fig. 7, B, it will be found that, in the lower anterior group, the cuspid and second bicuspid are present. Therefore place the right hand index finger on the fourth space from the top on the vertical index column on Plate 40, where these will be found. In the lower posterior group of this example will be found the second molar. Therefore, place the left hand index finger on the sixth space from the left on the horizontal index column, on Plate 40, where this will be found. The fingers are now caused to travel together at right angles, meeting in combination 44, Plate 40, which is the combination desired. Any combination may be found in like manner by this process.

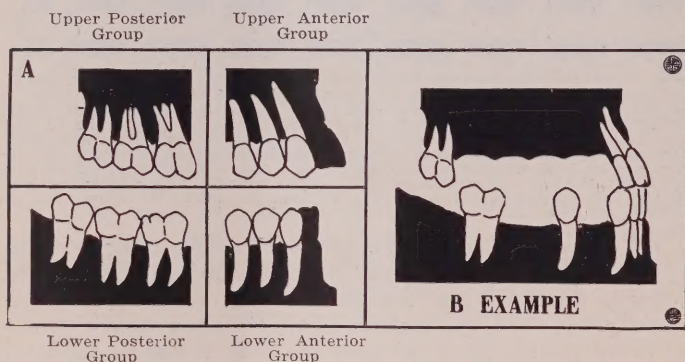
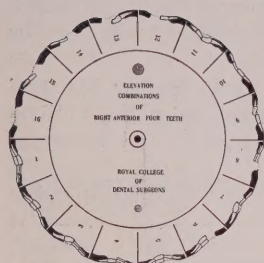


Fig. 7.—The Grouping for Index, and an Example. Section A is an example of the six posterior teeth divided into groups, namely: the anterior and posterior upper groups and the anterior and posterior lower groups. This grouping is for the purpose of locating, on the several Plates, any of the 4096 combinations, after the manner described in the text.

Section B is an example used to illustrate the use of the Index.

10.—Methods of Viewing all Combinations of the Eight Upper and Eight Lower Right Teeth, 2^{16} , or 65,536 Combinations.

The series just considered includes the combinations of the six upper and the six lower posterior teeth, amounting to 2^{12} , or 4,096 combinations. A method here follows by which ALL of the com-



A

COMBINATIONS OF FOURS					$2^4 = 16$	
					GROUPS	
1	A	B	C	D	FOURS	Section 4
2	A	B	C		THREES	Section 3
3		B	C	D		
4	A		C	D		
5	A	B		D		
6	A	B			TWOS	Section 2
7		B	C			
8			C	D		
9	A			D		
10	A		C		ONES	Section 1
11		B		D		
12	A					
13		B				
14			C		NONES	Section 0
15				D		
16						
TOTAL COMBINATIONS					16	

B

Fig. 8.—A. The circle for viewing all of the right combinations. To apply this circle, carefully cut it out along the edge of the teeth, and along the dotted line. B. Master Chart 2^4 from which it is derived, all of which is described in the text.

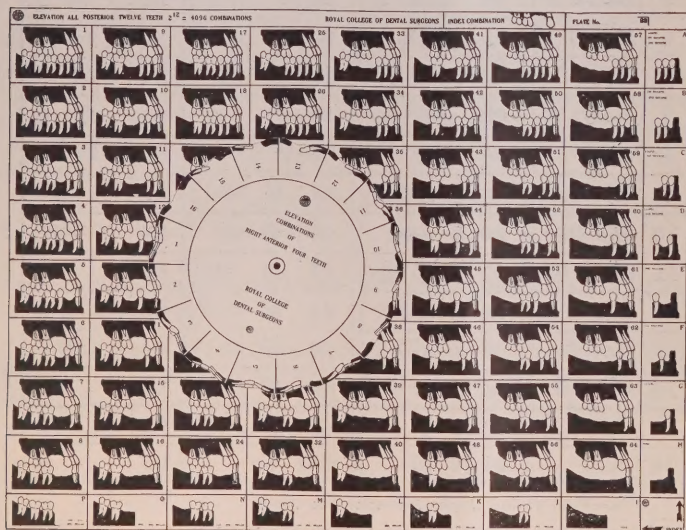


Fig. 9.—Showing the use of the Circle, as seen in Fig. 8, which is described in the text.

binations of the eight right upper and eight right lower teeth may be viewed, amounting to 2^8 , or 65,536 combinations.

In Fig. 8A will be noted a circle with 16 segments. On examination it will be seen that each segment contains each combination of the four anterior teeth on one side, namely, the right side, two upper and two lower teeth, ranging from all four present (segment No. 1) to none present (segment No. 16). This is made from 2^4 Master Chart as seen in Fig. 8, B, by the substitution method as used in Part III., Bulletin No. 6.* In this case the upper lateral is called A, the upper central B, the lower lateral C, and the lower central D, resulting in sixteen combinations.

Thus, by the application of this circle, containing sixteen combinations of the anterior four teeth, to each one of the 4,096 combinations, the total combinations of the sixteen teeth, 65,536, may be viewed.

To obtain all the combinations possible, apply segment No. 1 of the circle to the upper and lower cuspids of combination No. 1, Plate No. 1. Push a pin through the centre of the circle, and rotate the

PLAN COMBINATIONS OF SIXES — $2^6 = 64$ — ROYAL COLLEGE OF DENTAL SURGEONS															
SAME PROBLEM AS No.								PATIENT'S RIGHT SIDE							
1		17		1	33			49							
2		18		2	34			50							
3		19		3	35			51							
4		20		4	36			52							
5		21		5	37			53							
6		22		6	38			54							
7		23		7	39			55							
8		24		8	40			56							
9		25		SAME PROBLEM AS No.								9	57		
10		26			41			10	58						
11		27			42			11	59						
12		28			43			12	60						
13		29			44			13	61						
14		30			45			14	62						
15		31			46			15	63						
16		32			47			16	64						
					48										

Fig. 10.—Plan of the Upper Posterior six Teeth.

*Bulletin No. 6, Canadian Dental Research Foundation.

PLAN COMBINATIONS OF SIXES — $2^6 = 64$ —				ROYAL COLLEGE OF DENTAL SURGEONS				PATIENT'S RIGHT SIDE								
SAME PROBLEM AS No.																
1		17		33		49										
2		18		34		50										
3		19		35		51										
4		20		36		52										
5		21		37		53										
6		22		38		54										
7		23		39		55										
8		24		40		56										
9		25		SAME PROBLEM AS No.		9	57									
10		26		41		10	58									
11		27		42		11	59									
12		28		43		12	60									
13		29		44		13	61									
14		30		45		14	62									
15		31		46		15	63									
16		32		47		16	64									
				48												

Fig 11.—Plan of the Lower Posterior Six Teeth.

circle, so that each of the sixteen segments of the circle is applied in turn. Thus we have viewed sixteen different combinations from Combination No. 1, Plate No. 1. Repeat this process with the remaining 63 combinations of Plate No. 1, and also with the 64 combinations of each of the remaining 63 plates. Thus will be viewed the possible 65,536 combinations.

Fig. 9 shows the Combination No. 2 of the circle being applied to Combination No. 13, Plate 23.

11.—*Plan of Combinations, Both the Upper and Lower Posterior Six Teeth.*

These are reproduced from Bulletin No. 6, Canadian Dental Research Foundation, and may be noted in Figs. 10 and 11. These are for the purpose of study and comparison with the main series of this Bulletin, which is shown in elevation.

12.—*Total Number of Combinations between the Upper and the Lower Sixteen Teeth:— 2^{22} in Number.*

In the foregoing series only one-half the full dental complement is

indicated; namely, sixteen teeth of the right side only, totalling 2^{16} , or 65,536 combinations.*

Were it possible, or practical, to show the total combinations of all thirty-two teeth, upper and lower, the 65,536 right combinations would be multiplied by a further 65,536 left combinations, which is $2^{16} \times 2^{16} = 2^{32} = 4,294,967,296$ combinations:—four billion, two hundred and ninety-four million, nine hundred and sixty-seven thousand, and two hundred and ninety-six combinations.

13.—*Concluding Note.*

The methods employed in assembling the foregoing, and other series, is that of the use of Master Charts, built by a juxtaposition method, building up larger combinations from smaller ones. This method is described in detail, Section 14, Bulletin No. 6, Canadian Dental Research Foundation, and results in an arrangement which lends itself admirably for indexing, as shown, and also for checking and cross checking for accuracy.

For other research purposes, however, different arrangements of the several combinations may be desired for the special objects of the individual research worker. If so, the Canadian Dental Research Foundation would gladly offer any facility, such as, for example, the loan of electros already made, to local printing concerns, giving the investigator every facility for taking the printed pictures resulting therefrom, and rearranging, and if necessary from his viewpoint, eliminating, for the purpose of classification, or carrying out standardization, of pictures of combinations, far more suitable and of larger proportions than at all possible on the printed page.

*In order to show the 65,536 combinations on the right side, 15 more charts similar to the one attached would be required. In order to show the total combinations of both sides, 1,048,575 more charts similar to the one attached would be required.

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- No. 6—Combinations as an Aid in the Discovery of Fundamentals in Dentistry and other Sciences, May, 1923, W. E. Cummer, G. R. Anderson, Robert J. Reade. (71 pages, 120 Illustrations).
- No. 7—Studies in Peridontal Pathology; The Mechanics of Occlusion, Summary of the Signs of Incipient Peridontal Disease (Issued in Conjunction with the Department of Health, Province of Ontario), May, 1924, H. K. Box, G. R. Anderson. (120 pages, 135 Illustrations).
- No. 8—Articulation for Partial Dentures with the Snow Apparatus and Wadsworth Incisor Guide, June, 1924, W. E. Cummer, I. H. Ante, J. A. Bothwell. (45 pages, 39 illustrations).

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TREATMENT
OF THE
PERIODONTAL POCKET

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TREATMENT OF THE PERIODONTAL POCKET

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TORONTO
THE UNIVERSITY OF TORONTO PRESS
1928

binations of the eight right upper and eight right lower teeth may be viewed, amounting to 2^8 , or 65,536 combinations.

In Fig. 8A will be noted a circle with 16 segments. On examination it will be seen that each segment contains each combination of the four anterior teeth on one side, namely, the right side, two upper and two lower teeth, ranging from all four present (segment No. 1) to none present (segment No. 16). This is made from 2^4 Master Chart as seen in Fig. 8, B, by the substitution method as used in Part III., Bulletin No. 6.* In this case the upper lateral is called A, the upper central B, the lower lateral C, and the lower central D, resulting in sixteen combinations.

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		SAME PROBLEM AS No.													
1		17		1	33		49								
2		18		2	34		50								
3		19		3	35		51								
4		20		4	36		52								
5		21		5	37		53								
6		22		6	38		54								
7		23		7	39		55								
8		24		8	40		56								
9		25		SAME PROBLEM AS No.		41		9	57						
10		26			42		10	58							
11		27			43		11	59							
12		28			44		12	60							
13		29			45		13	61							
14		30			46		14	62							
15		31			47		15	63							
16		32			48		16	64							

Fig. 10.—Plan of the Upper Posterior six Teeth.

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		SAME PROBLEM AS No.					
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2		18		34		50	
3		19		35		51	
4		20		36		52	
5		21		37		53	
6		22		38		54	
7		23		39		55	
8		24		40		56	
9		25		41		57	
10		26		42		58	
11		27		43		59	
12		28		44		60	
13		29		45		61	
14		30		46		62	
15		31		47		63	
16		32		48		64	

Fig 11.—Plan of the Lower Posterior Six Teeth.

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- Nos. 3 and 4—The Dentinal-Cemental Junction; Histological and Histo-Pathological Studies of the Dental Pulp, May, 1922, H. K. Box. (60 pages, 82 Illustrations).
- No. 5—The Science and Practice of Partial Denture Service, with Special Reference to a Graphic Method of Design, May, 1922, W. E. Cummer. (27 pages, 16 Illustrations).
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14

TREATMENT
OF THE
PERIODONTAL POCKET

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TREATMENT OF THE PERIODONTAL POCKET

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FOREWORD

IT is with great pleasure that I present a few words of appreciation of the work contained in the present treatise by Dr. Harold K. Box. Naturally, I view this work from the standpoint of my own special interest in dentistry, namely, the prevention of dental and oral diseases. Histo-pathology represents an important unit in the field of prevention and the dental profession is progressing steadily towards that goal.

In addition to Dr. Box's research work, which he began in 1914 as Research Fellow in this Faculty, he has been engaged in the practice of Periodontia. In this bulletin we find a very happy linking up of the scientific and clinical phases of the problem, which greatly adds to its practical value. Although Dr. Box has continued practice throughout these years, his major interest has always been that of dental research, and the degree of concentration which has marked his sustained effort has at times been such as to seriously affect his health.

Effective control of periodontal disease means the elimination of much focal infection, the saving of untold numbers of teeth and the consequent preservation of a normal masticating mechanism. The publication of this work makes a substantial contribution to dentistry and is, I believe, another important step forward in this branch of science.

WALLACE SECCOMBE.

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INTRODUCTION

For some years past I have taken an increasing interest in the histo-pathology of periodontal disease, believing that rational treatment must be founded in large part on the histo-pathologic findings. I say this with full realization that remarkable success was being achieved by an increasing group of periodontists whose methods of practice were largely empirical. The "Studies in Periodontal Pathology," published in 1924, represented my conception of periodontal pathology, a conception which has found rather wide acceptance since its introduction to the profession. Since that time I have devoted myself to further study in this field with the idea of subjecting the theories propounded to a severe scrutiny. As a result of this study, some slight modifications of my former viewpoint have been made, but the theory of periodontal pathology in its main aspects seems definitely to be affirmed by these later studies.

The application of the theories advanced in 1924 has also engaged my attention, and there has resulted the development of a definite treatment for the periodontal pocket which is presented in this treatise. The results which have been obtained by following the routine as herein described have been most gratifying. This method is therefore presented to the profession with the hope that it will be given a fair trial by those interested in this branch of dental practice, and with the hope that from this there may arise some benefit to the very large number of people in the community who suffer from the various phases of periodontal disease.

HAROLD KEITH BOX.

PART I

GENERAL DISCUSSION OF POCKETS

Chronic Periodontitis of the pocket-producing type may be divided into two main classes which differ greatly in the aggregate of associated symptoms. These are known as Complex and Simplex Periodontitis.

In the first class, the Complex, the formation of the pocket is usually preceded by a gingivitis. Since gingivitis is also found in the Simplex Periodontitis, it is important to differentiate the underlying type of disease. In the Complex Periodontitis profound structural changes precede the appearance of the gingivitis. These are found in the deeper tissues where a chronic and progressive lesion of the pericementum has resulted in a change of its normal arrangement and a rarefaction of the alveolar bone. This underlying lesion termed Rarefying Pericementitis Fibrosa is for a time at least the dominating one.

The syndrome or grouping of associated symptoms in Complex Periodontitis is as follows:

(1) This type is characterized by uneven distribution of sites which, as a rule, are localized by traumatic occlusion.

(2) Axial extrusion or lateral drifting with the formation of a diastema are early signs.

(3) Increased mobility of the tooth in its alveolus is also an early sign; the looseness is due to the widened pericemental space.

(4) Pocket formation is, as a rule, a relatively late symptom; usually of fairly rapid development; deep, narrow and with its base variable in position in relation to the pocket opening, and occurring usually on the side of tension or pull.

(5) Gingival inflammation is usually an inconspicuous feature in the syndrome; serumal calculus is often scant in amount; salivary calculus frequently wanting.

(6) The teeth, as a rule, present a high degree of immunity to caries.

Instrumentation alone has little bearing upon the factor of tooth-mobility; on the other hand, occlusal equilibration is followed, as a rule, by a marked tightening of the tooth in its alveolus.

In the second class, the Simplex, there is presented a simple reaction to bacterial invasion whereby through local lowered resistance, infection has been established. The gingival lesion is the dominating one. With progression of the infection from the gingivae the alveolar bone is next involved, the pericementum, as a rule, being the last periodontal component to be included. The causative factors are mainly superficial, such as deposits on the teeth and the presence of any holding medium for bacteria, such as sticky foods. As a rule, this type is seen in man where there is a lack of proper dental hygiene.

The syndrome in Simplex Periodontitis is as follows:

(1) This type is characterized, as a rule, by a fairly even distribution of sites which tend to become localized by such factors as inadequate hygienic measures and mouth-breathing.

(2) Gingival inflammation dominates the clinical picture; calculus is usually present in abundance.

(3) Increased mobility of the tooth in its alveolus is a relatively late symptom in the progress of the disease; in other words, there is little divergence from normal mobility in the early stages.

(4) Pocket formation is frequently an early symptom; usually slower in development than the pocket of Complex Periodontitis; shallow, wide and with special predilection for the interproximal tissues.

(5) The teeth frequently show a susceptibility to caries.

Careful instrumentation is followed, as a rule, by a rapid reduction of the gingival and periodontal inflammation.

Sequence of Events in Pocket Development on the Cementum

(1) Detachment of the principal fibres from the cementum. The main factors that bring this about are:

(a) Infection.

(b) Trauma, viz.—food impaction, traumatic occlusion, improper tooth-brushing.

(c) Diminished vitality of the cementum (Gottlieb).

(2) Epithelial proliferation to cover the detached connective tissues. Organic union with the tooth is at the same time maintained.

(3) Separation of the tissues from the tooth surface:

- (a) Before cuticle formation.
- (b) After cuticle formation.

The following factors tend to establish deep pockets:

(1) Failure of the gingival tissues to atrophy.

Frequently topographic conditions are present which prevent gingival atrophy with consequent deepening of the pocket. The following are examples:

(a) Narrow pocket on a broad root surface, in other words the typical complex pocket. When the face of the pocket formed by the soft tissue wall is fairly narrow, the gingival margin of the detached tissues through the proximity of the lateral borders of the pocket is not permitted to follow the pocket base. Examples are commonly found on the lingual and labial of upper centrals and cuspids.

(b) Comparatively broad pockets on a narrow root surface present similar conditions. Here the pocket type may be of the simplex variety, but the root-surface being narrow, topical conditions are presented which prevent gingival atrophy. Examples are frequently to be noted on the lower incisors.

(c) Topical conditions are constant at the distal of Lower Third Molars, where the gingival margin, through its junction with the adjacent soft tissues, is unable to follow the pocket-base.

(d) Similar conditions are presented in extraction-spaces where the gingival margin is joined with the alveolar mucosa, and is not permitted to follow the pocket-base, *e.g.*, mesial pockets on Lower Second Molars where the First Molar has been extracted.

(2) Failure of the tooth to drift under undue stress. It has been the observation of the author that when tooth-movement is not permitted in the presence of traumatic occlusion, that pocket-formation is usually deep and narrow. Orthodontic retaining appliances holding teeth against manifest traumatic occlusion; bridges, partial dentures, contact points, and dense alveolar bone are examples in which tooth-movement is impeded or prevented in the presence of overstress.

(3) Gingival swelling or hyperplasia—with increase in gingival thickness or height increases the depth of the pocket.

Conversely the following factors tend to keep the pocket shallow:

(1) Gingival Atrophy.—It is obvious that when the

gingival margin is able to make parallel progress with the extension of the pocket-base, that depth of the pocket remains constant. This is commonly observed as a sequel of Simplex Periodontitis.

(2) Tooth-movement, under traumatic occlusion.—The writer has observed clinically that drifting teeth where the movement has been slow, frequently present fairly shallow pockets which occur on the side of tension or pull. There is also some microscopic evidence which appears to show that with early pocket formation and slow tooth-movement the pocket tends to remain shallow. Under microscopic examination a tooth which has suffered a slow displacement and movement shows a development of a narrow wedge-shaped mass of soft tissue to fill in the gap on the side of pull, developed through the drifting of the tooth. The base of this wedge is towards the gingival crevice, and is bordered on the side away from the tooth by a row of epithelial cell-rests indicating the original position of the tooth. The present relationship of these cell-rests to the tooth-root would indicate that the fulcrum of the drifting tooth was situated a short distance from the apex. In section, the perimeter of the new crevicular surface presents a disproportionate relation to the perimeter of the denuded cemental surface further showing that new tissue has been developed to fill in the break.

This new tissue closely resembles the normal stroma in the gingiva except where in its upper portion it is in contact with the pocket. Here a granulation tissue makes its appearance with the formation of many blood-vessels. This granulation tissue is still active although it is clothed on its surface by the crevicular epithelium.

Furthermore, the pocket-outline presented tends to the production of a horizontal floor which makes for shallowness and the maintenance of hygienic conditions. It seems probable that with slow movement and compensatory soft-tissue development, in pocket-formation, the detachment of the fibres makes somewhat slower progress in its advance towards the apex. It is possible that this principle has a definite bearing on the clinical observations of teeth which are drifting under the influence of traumatic occlusion.

(3) Absence of swelling, *e.g.*, in chronic inflammation of the gingivae; absence of hyperplasia; and decrease in gingival swelling following treatment.

The bearing of these principles upon practice:

(1) Gingival Atrophy.—As pointed out previously, when the topographical conditions are such that the gingival margin is allowed to follow the pocket-base, through gingival atrophy, the pocket depth cannot increase. Such broad, shallow pockets, noted in Simplex Periodontitis, are familiar to all periodontists. These pockets obviously from a hygienic stand-point, present decided advantages over the narrow and deep pockets seen in Complex Periodontitis. Frequently, however, where the local conditions do not permit gingival atrophy, certain measures may be undertaken to facilitate this change. Deep and narrow pockets where atrophy is impeded, or where reattachment is not secured, when split to the base, or at least to some distance, or through the removal of narrow, wedge-shaped segments of tissue with a periodontal bistoury, are made to simulate simplex pockets as the gingival tissues retract. Thus the deep pocket is eliminated and an extensive shallow one more favourable to the establishment of hygienic conditions is created.

(2) Drifting.—It was pointed out previously that with early pocket formation and slow tooth-movement the pocket, as a rule, tends to remain shallow. It is obvious that when traumatic occlusion is present, its relief is the logical measure to be undertaken. Fixation of the tooth without the relief from the overstress tends to hasten pocket-extension.

(3) Decrease in gingival swelling through reduction of the inflammation.—It has been shown that through swelling or hyperplasia, and consequent increase in gingival height, the depth of the pocket is increased. Any measure that tends to reduce the inflammation such as scaling, brushing and medication, through decrease in gingival height, obviously tends to make the pocket shallow. And with actual curettement and consequent contraction of the soft tissues the minimum pocket depth is achieved, apart from excision of the gingival tissues. Figs. 1-8.

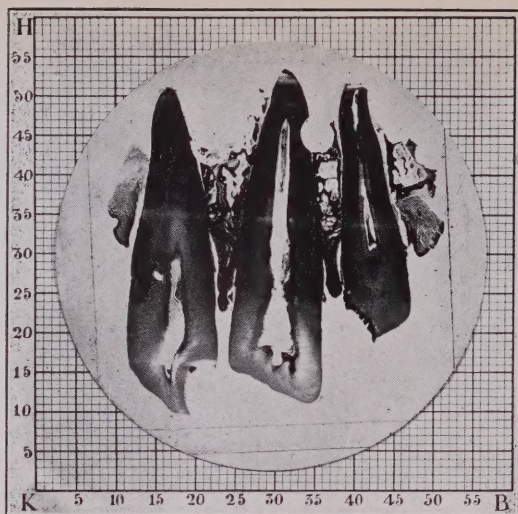


FIG. 1—X3. PERIODONTAL POCKETS (HUMAN)

This low magnification of Upper Centrals and Lateral shows six proximal pockets of varying depths.

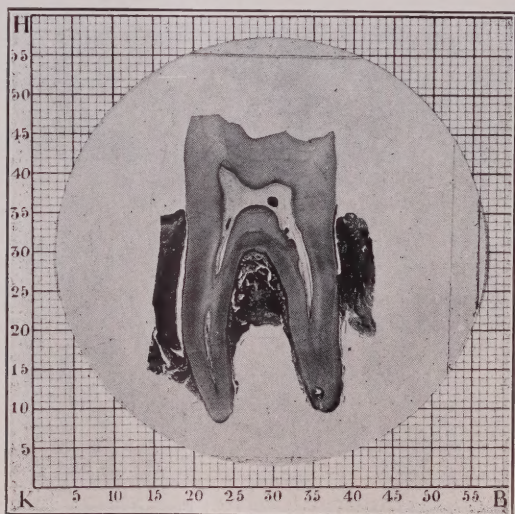


FIG. 2—X3. PERIODONTAL POCKETS (HUMAN)

This extremely low magnification of the Lower Right First Molar shows mesially and distally very deep pockets. The mesio-proximal pocket is seven millimeters deep.

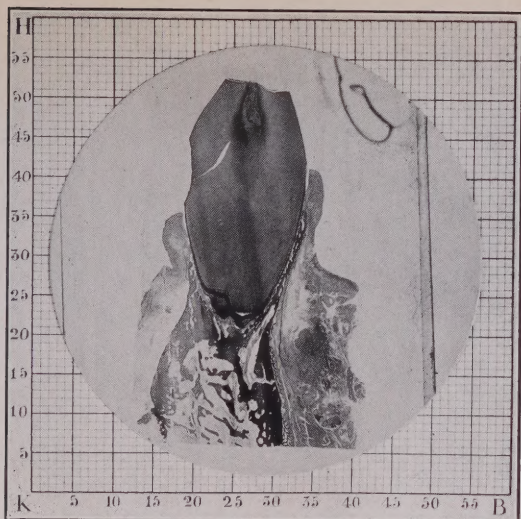


FIG. 3—X2½. PERIODONTAL POCKETS (HUMAN)

Extremely low magnification of longitudinal section of Lower Right Molar showing buccal and lingual pockets. These pockets are relatively shallow due to gingival atrophy.

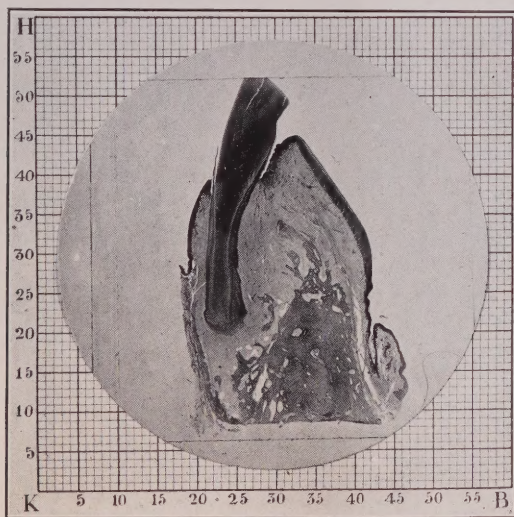


FIG. 4—X3. PERIODONTAL POCKET (SHEEP)

This illustration shows a fairly deep pocket on the lingual of a lower incisor, which in the sheep is on the side of tension or pull. On the side of compression or push the pocket is shallow, due to the atrophy of the gingival tissues.

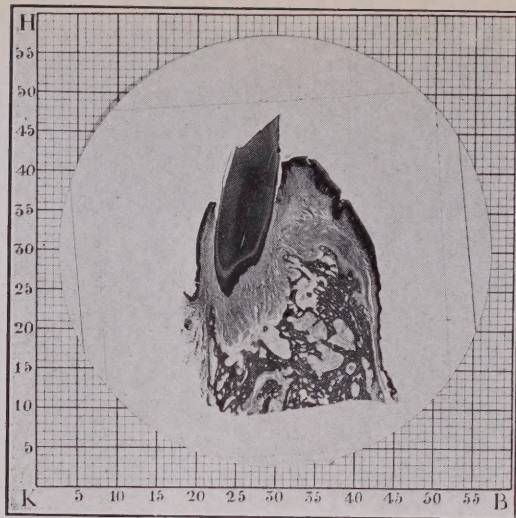


FIG. 5—X3. PERIODONTAL POCKET (SHEEP)

Here again is shown a deep pocket on the side of tension, while the compression-side presents a pocket of fairly shallow depth.

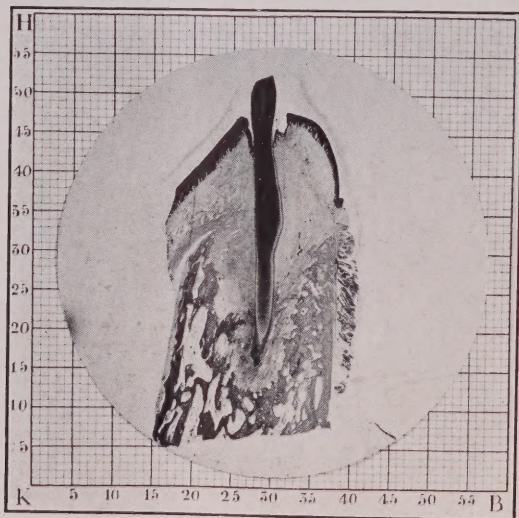


FIG. 6—X3½. DRIFTED TOOTH AND SUPPORTING TISSUES (SHEEP)

The pocket on the right of the illustration is on the side of tension or pull.

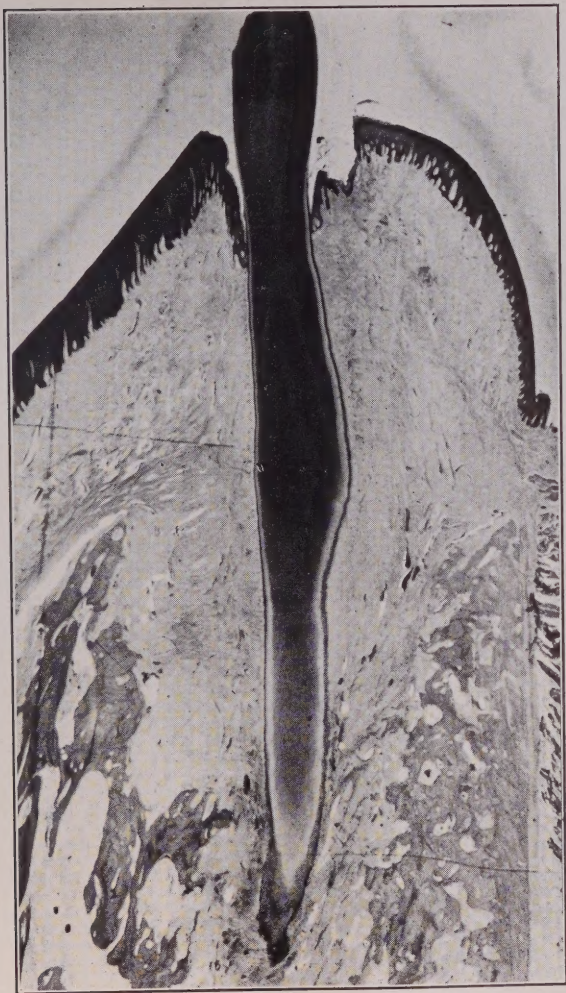


FIG. 7—X11. DRIFTED TOOTH AND PERIODONTAL TISSUES (SHEEP)

Note that the pocket on the right of the tooth, the side of pull in the gingival zone, is shallow and presents a horizontal floor. Beneath this there is demonstrated a narrow wedge-shaped mass of soft tissue with its base towards the gingival crevice. This tissue has been developed through the slow drifting of the tooth. Note the row of epithelial cell-rests on the border of the soft tissue wedge.

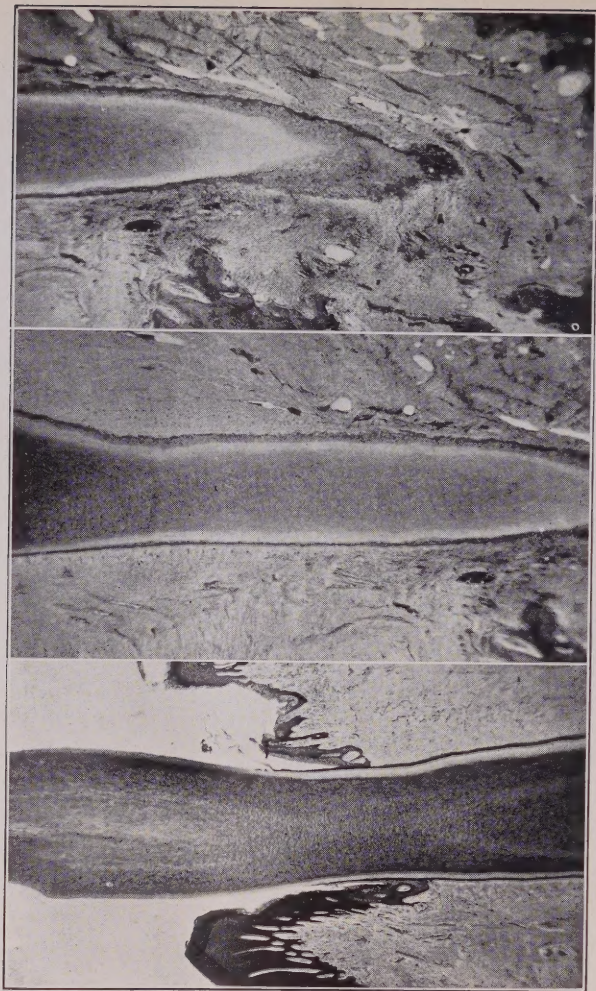


FIG. 8—X40. GINGIVAL, MIDDLE AND APICAL ZONES OF DRIFTED TOOTH

In the first illustration, the gingival zone, the perimeter of the new crevicular surface on the side of pull is clearly shown. Note the disproportionate relationship between this surface and the denuded cemental surface. The row of epithelial cell-rests bordering the new tissue developed to fill the break is also faintly shown. The distance of the rests from the tooth, at the gingival crevice on the side of pull (right), is five times that of the rests on the opposite side, the side of push.

In the second illustration, the middle zone, the fulcrum of the drifting tooth is indicated by the present relationship of the epithelial cell-rests. On the right side, near the lower third of the photomicrograph, the lines formed by the row of cell-rests and the root-surface tend to converge, while on the opposite side, on the same plane, they tend to diverge.

In the third illustration, the apical zone, the relationship of the cell-rests to the root-tip is also demonstrated. On the left side, in this case, the side of pull, the cell-rests are much farther away from the cemental surface than on the right side, which is the side of push.

Rarefying Pericementitis Fibrosa

Rarefying Pericementitis Fibrosa has been defined by the writer¹ as a "chronic and progressive lesion of the pericementum which results in the rarefaction and destruction of the alveolar bone. The process consists of the formation in the pericementum of a new tissue which, on the one hand, changes the normal arrangement of the pericemental structures and, on the other, replaces the bone substance of the alveolar process. These changes in the pericementum and the alveolar bone are concomitant lesions. This new tissue subsequently assumes the form of a fibrillar connective tissue."

Important Histologic Features of Rarefying Pericementitis Fibrosa

(1) It is an inflammatory lesion in contrast to being a lesion of degeneration of the surrounding tissues. The newly-formed connective tissue is definitely a productive fibrosis of inflammatory origin. To refer to it as "fibroid degeneration" of the pericementum is erroneous as the term is a misnomer. There is presented in the pericementum a type of inflammatory fibrous tissue-development, that is to say, a form of pericementitis. Adami² has stated "The overgrowth of any tissue, however lowly, is not a degeneration." That degenerative changes, chiefly the hyaline, frequently occur in fibrous connective tissue is generally recognized; in those processes, however, another matter is under consideration. It would be equally wrong to speak of every condition of localized fibroid change as a chronic inflammation as certain conditions of fibrosis are encountered which cannot be looked upon as the result of injury.

(2) The inflammatory process is largely denoted in the earlier phases by the presence of plasma cells, lymphocytes, endothelial cells and only rarely a polymorphonuclear cell. It is never suppurative in the beginning. Only rarely does one observe degeneration with some debris in the tissue.

(3) The inflammatory process is of a low grade progressive type in which even in the early phases there is a connective tissue proliferation in the involved areas.

(4) This progressive inflammation produces slowly but definitely an increase in connective tissues. These connective tissues involve the constituent structures in the area, and principally the vascular

channels in which we note that the arterioles are more affected than the venules.

(5) The vascular changes consist in large part of a concentric perivascular fibrosis and to a varying degree a thickening of the inner endothelial layer of the arterioles. These two types of reaction occurring in the vessel-wall do not always progress equally, for in many vessels the perivascular thickening is much greater than the increase in the inner layer of the arterioles. In other instances, however, and this seems particularly true of the small arterioles, an endothelial hyperplasia gives rise to a concentric thickening of the intima with narrowing of the lumen. In the excised tissues under examination these small arterioles occasionally appear completely obliterated through the presence of these reactive processes. It may be, of course, that the narrowing of the lumen becomes further exaggerated through the contraction of the arterial wall after removal.

(6) From this we would conclude that nutritional disturbances arise affecting the specific tissues of the part, particularly bone. Atrophy of the bone occurs in this stage.

Harmful Sequelae of Rarefying Pericementitis Fibrosa

(1) With the formation of the new tissue in the pericementum, and through increase in size of its various perivascular nodules, many principal fibres are severed, thus altering the functional conditions of the pericementum as a whole; at the same time the alveolar bone associated with these fibres loses the functional stimuli necessary for its normal building and repair.

(2) By absorption of bone through encroachment of the new tissue upon the alveolar surface, together with the loss of bone through atrophic changes, the inner wall of the alveolus is removed. Thus there is permitted an increased mobility of the tooth in its alveolus beyond the normal. This mobility is a factor which accelerates the rate of progression of the disease processes including infection if established.

(3) Loss of alveolar bone on the crest of the process through the initiation of the lesions of Pericementitis Fibrosa in the gingival third of the pericementum increases the length of the extra-alveolar lever arm, thereby intensifying the production of over-stress in the remaining pericementum.

(4) The blood supply of the gingivae is derived in part from the pericemental blood-vessels. When the tissue changes in Pericementitis Fibrosa occur in the gingival third of the pericementum, associated so often with traumatic occlusion produced by horizontal overloading, a disturbance of the circulation of the gingivae follows, thus producing a state of local lowered resistance. This lowered resistance, the close proximity of the gingival crevice with its bacteria and epithelium, and the peculiar character of the new tissue in the underlying pericementum, form the ideal requisites for rapid and deep pocket formation.

(5) Lesions occurring in the apical third and thus being remote from the gingivae do not tend to induce gingival disturbances. On the other hand, evidence is not lacking to support the view that these lesions constitute the active factor in the axial extrusion of the tooth from its alveolus, and in lateral drifting with the production of diastema. Figs. 9-13.

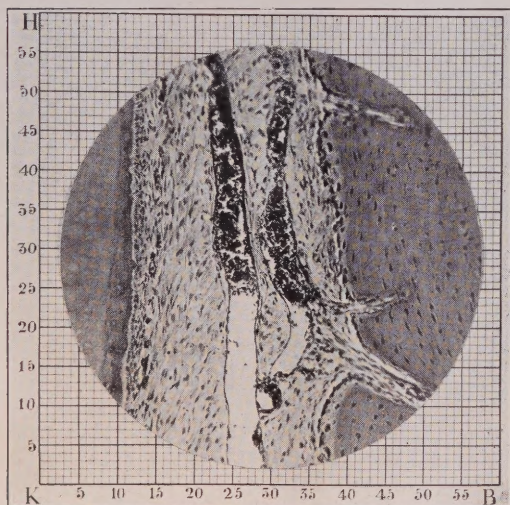


FIG. 9—X100. NORMAL PERICEMENTUM WITH DEVELOPING CEMENTUM
(BOY—AGE 12)

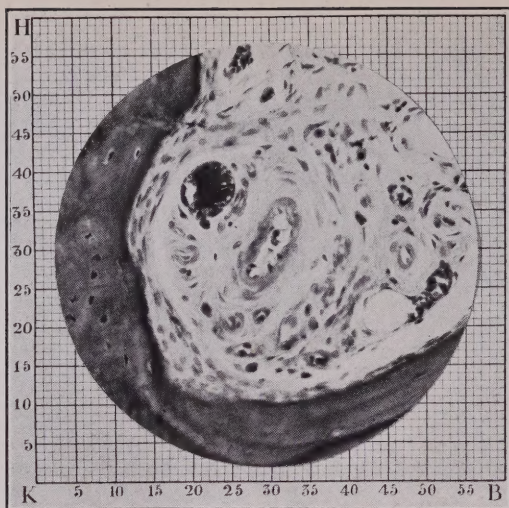


FIG. 10—X265. RAREFYING PERICEMENTITIS FIBROSA (HUMAN)
In this photomicrograph the blood-vessel in the centre of the field presents a marked concentric perivascular fibrosis.

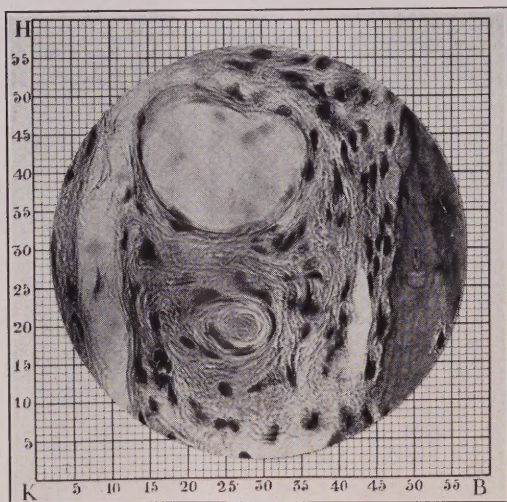


FIG. 11—X530. RAREFYING PERICEMENTITIS FIBROSA (HUMAN)
This photomicrograph shows a concentric thickening of the inner lining of the arteriole, HK 20, KB 27, apparently with complete obliteration of the vessel lumen.

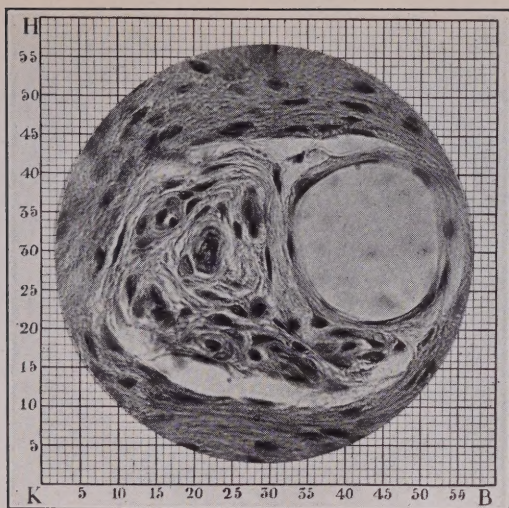


FIG. 12—X530. RAREFYING PERICEMENTITIS FIBROSA (HUMAN)
This photomicrograph also shows a concentric thickening of the inner lining of the arteriole
HK 30, KB 22. Here also the lumen of the arteriole appears to be completely obliterated.

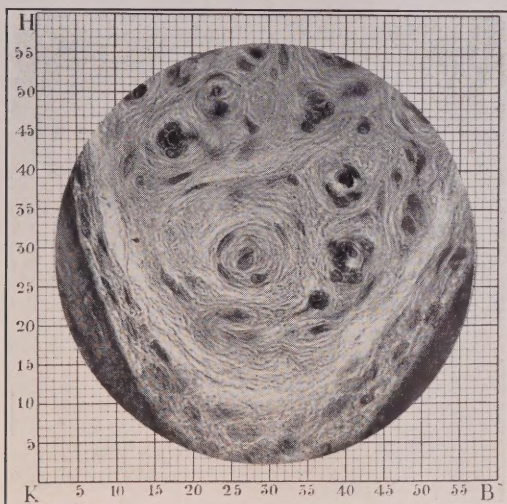


FIG. 13—X530. RAREFYING PERICEMENTITIS FIBROSA (HUMAN)
Through concentric thickening of the inner lining of the arteriole, HK 32, KB 27, the lumen
of the arteriole has been obliterated.

Physiological Occlusion

Physiological occlusion has been defined by the writer³ as a condition in which the systems of forces acting upon the tooth during occlusion are in a state of equilibrium and do not and cannot change the normal relationship existing between the tooth and its supporting structures. In other words, physiological occlusion is present when the periodontium is able to withstand the forces of occlusion without the initiation of pathological changes in the pericementum. Upon the proper appreciation of this tenet depends in a large measure our understanding of traumatic occlusion. The relationship between the tooth and its periodontal tissues in normal occlusal function is harmonious, and the tissues are permitted to remain in a healthy and quiescent state wherein they are best able to resist harmful influences of various kinds which bring about morbid changes in them.

Physiological occlusion is manifested clinically in two forms:

(a) VERTICAL LOADING—in which the applied occlusal force is exerted in the direction of the long axis of the tooth. Anderson⁴ has stated that the compressural stress on the pericementum will be greater at the apex than along the side in proportion to the length of the root compared to its diameter, provided the root is not distinctly cone-shaped. This is to be observed frequently in the so-called end-to-end occlusion, in which, by the way, there is frequently a tendency to overloading.

(b) HORIZONTAL LOADING—in which the applied occlusal force is exerted in a direction oblique to the long axis, with consequent force-resolution and torque-production. The compressural stress on the pericementum will be greater in the gingival third of the side away from the point of application of the force and in the opposite apical third.

In both vertical and horizontal loading the occlusal pressure against the tooth is balanced by the resistance of the periodontal tissues.

Traumatic Occlusion

Traumatic occlusion has been defined by the writer as a condition in which the systems of forces acting upon the tooth during occlusion are not in equilibrium. The tooth may be regarded as a

rigid body whose size and shape always remain the same whatever forces be applied to different parts of it. In occlusal function the tooth is acted upon by two groups of forces, viz., the applied occlusal stress exerted on the crown, and the resisting periodontal stress furnished by the periodontium and exerted on the root. As pointed out previously, in physiological occlusion these groups must balance, the compression or tension on the pericementum being such that pathological changes will not be initiated in it thereby. In traumatic occlusion, however, the relationship between these groups is such that overstress and overstrain are produced in all or part of the pericementum.

Overstress in the pericementum is the physical agent, overstrain the state produced by it and Rarefying Pericementitis Fibrosa, a resultant lesion.

The *modus operandi* of traumatic occlusion may best be comprehended if we keep in mind the fact that this stress is normal in kind but not in amount. Moreover, it should be borne in mind that occlusal overstress is not so great in amount, as a rule, that any closure of the jaws produces immediate mobility, *i.e.*, the tensile strength of the pericementum is not exceeded in any of the usual manifestations of traumatic occlusion. But when the pericementum is subjected to a great many repetitions of overstress which are well below its tensile strength, as a rule, it is greatly weakened thereby, and it may finally be injured by a load which it would have easily carried at first. This is well exemplified in the act of swallowing when, as is well known, the teeth are in centric occlusion. Through uneven occlusal abrasion the balancing inclines of molars are frequently lost and in centric occlusion, pericemental overstress through abnormal torque-production is induced; and in swallowing,⁵ this condition, though possibly moderate in degree, is repeated hundreds of times daily. This factor of repetition enters into the whole question of traumatic occlusion, becoming especially significant in certain nervous habits. Figs. 14-15.

As in physiological occlusion, traumatic occlusion is manifested clinically in two forms, viz., Vertical and Horizontal Overloading:

(a) VERTICAL OVERLOADING.—The applied occlusal force is exerted in the direction of the long axis of the tooth, and the tooth is subjected to intermittent pressure greater than it should be called upon to bear. The compressural stress on the pericementum at the apex is excessive, and the tissue

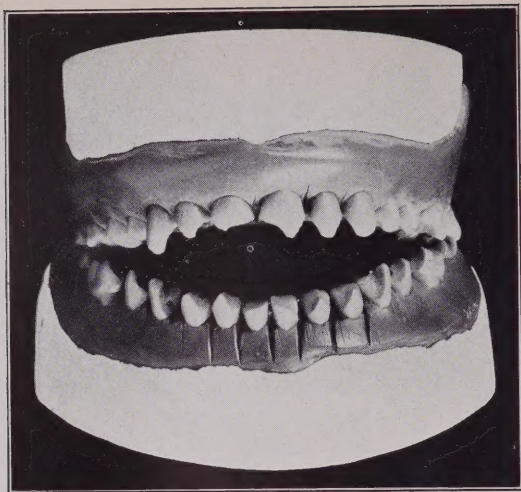


FIG. 14—EXTREME OCCLUSAL ABRASION IN ARTIFICIAL DENTURES

These dentures were made in 1921 for a patient 65 years of age who had been a seamstress.

The extreme abrasion of the teeth to be noted in the photographs was produced in four years. The main factor concerned in the process was undoubtedly a nervous habit of almost constant biting and grinding of the teeth, a habit probably developed during the patient's occupation as seamstress. (Courtesy of Dr. H. C. Arnott, Oshawa, Ont.)

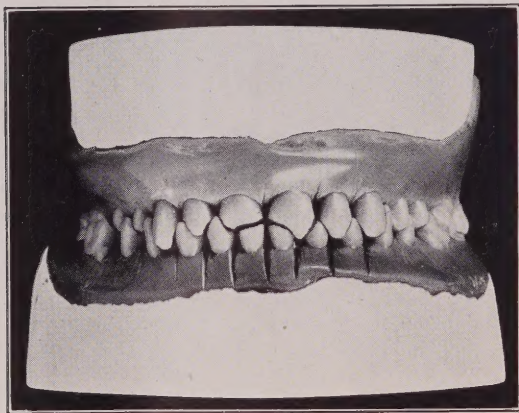


FIG. 15—EXTREME OCCLUSAL ABRASION

This photograph of the dentures shown in Fig. 14 shows their relation in centric occlusion. Note the exaggerated sharpness and pointedness of the cusps.

alterations occur in the periapical zone, the radiograph being the logical means of their detection.^{6,7} These changes are remote from the gingival crevice with its bacteria and epithelium, and have little or no direct bearing on pocket formation. From the foregoing it is obvious that sound clinical opinions cannot be expressed as to the presence or absence of incipient structural changes in the periodontium, from traumatic occlusion of the vertical overloading type, without a careful examination of the radiograph in the periapical zone. To seek in the gingival tissues only for the early signs of tissue-changes is to make a periodontal examination which is not based on the modern concept of the subject, viewed from statical, pathological and clinical standpoints.

(b) HORIZONTAL OVERLOADING.—The applied occlusal force is exerted in a direction oblique to the long axis, and may be resolved into a vertical force acting along the axis, and a horizontal one at right angles to it. This horizontal force, or normal component as it is sometimes called, enters into the production of an abnormal torque which creates overstress in the pericementum of the gingival third and of the apical third. The overstress in the gingival third of the side away from the point of application of the force—the push side as it is called—is one of compression; and on the opposite gingival third—the pull side—is one of tension.

The gingival third of the pericementum, apart from being a zone of overstress and trauma in horizontal overloading, and especially pernicious at the alveolar crest, is a peculiarly vulnerable region. Its proximity to the gingival crevice with its bacteria ever ready to invade the gingival tissues and establish infection, and its epithelial attachment inherently predisposed to cover the detached soft tissues by inward growth along the cementum, makes it especially liable to involvement by these processes. Further, as Gottlieb has pointed out, the ability of the pericementum to form reparation-cementum (reparative in that it retards the down-growth of epithelium and opposes the widening of the pericemental space), decreases towards the neck of the tooth.

It is obvious, therefore, from the foregoing that conditions in

the gingival third of the pericementum must have a most important bearing on the type of pocket formation.

Overstress, in horizontal overloading, with its consequent increase of liability to infection, or actual cellular alterations, in this region, prepares the tissues for inevitable involvement from superimposed gingival infection; and there is developed, as a rule with rapidity, a pocket which is narrow, deep, and with base varying greatly as to position, all being recognized characteristics of Complex Periodontitis.

A Classification of Traumatic Occlusions

The production of overstress in the pericementum is dependent on a disturbed relationship between the applied occlusal stress and resisting periodontal stress; one or the other of these factors must be abnormal, and it follows as a complication that both factors may be abnormal with the result that pathological changes are accelerated and the tooth, as a rule, soon lost.

On this distinct basis, according to the mode of origin, traumatic occlusions may be classified into the following three groups:

(1) PRIMARY.—Abnormal occlusal factor with normal periodontal factor; the magnitude of the original force is so excessive, or the manner in which it is delivered is such that overstress is produced in the pericementum.

Examples:

(a) *Cusp interference* in unbalanced occlusion,⁸ and unbalanced articulation, malocclusion, faulty dental restorations, mixed typical tooth-forms, and certain types of completed orthodontic cases that fail to comply with the laws of balanced articulation present, as a rule, examples of cusp interference. Abnormal torque-production through horizontal overloading is introduced with consequent zones of overstress in the pericementum. When the teeth are of normal size and there is retarded physical development in one or both of the jaws, malalignment and malocclusion must result; and with consequent disharmony of the occlusal relations of the teeth in function, the pernicious element of horizontal overloading is usually introduced.

Recently, in a most valuable contribution, Sir Arthur Keith⁹ has pointed out that misplacements of the teeth, long narrow dental arches, and high vaulted palates, which are so

prevalent among Englishmen of to-day, were almost unknown amongst the British people of the neolithic and early bronze periods. He has stated that while we see teeth, jaws, and faces of modern skulls just as symmetrically developed as in ancient times, this condition occurs in markedly diminished proportion. He found that ancient skulls never presented cases of contracted and irregularly developed palates; in modern British people there is a tendency of the palate to grow longer, and with greater vaulting. In a survey of palates and jaws of British people, fifty ancient (buried in England before the date of the Norman Conquest) and fifty modern skulls (chiefly Londoners of the eighteenth and nineteenth centuries) were taken, and the evidence showed definitely that changes of a measurable amount are affecting the teeth, jaws, noses, orbits and cheeks of the Englishmen of to-day. It is of extreme interest to note that forty-seven of the dentures of the ancient British skulls presented an end-to-end occlusion in the incisor region, while all of the modern skulls showed definite overlapping in the same region. The significance of these important findings is tremendous from the viewpoint alone of traumatic occlusion production. This gradual transition from an end-to-end centric occlusion to one of overlapping implies a change from vertical to horizontal loading in the anterior region; and with failure of the compensating curves to permit a balanced occlusion and articulation in the protrusive ranges, as is so often the case, horizontal overloading is introduced, with its consequent traumatic occlusion.

House¹⁰ has pointed out that traumatic occlusion may result through the presence of a mixture of typal forms or modifications in their many combinations. The three typal or basic forms, namely, square, tapering and ovoid are found but seldom in the pure type, modifications due to the combination of these types predominating because of the mixing of the species. Through typal combinations, as well as impaired development, asymmetric forms are produced introducing incorrect cuspal interdigitation and incoordination with the working paths.

(b) *Uneven Wear*.—The production of facets on occlusal

surfaces, through attrition, by the increase of the torque-component of the original force tend to greater torque production.

Facets and concavities are not original characteristics of the inclined surfaces of the cusps. Hirschfeld¹¹, in describing the mechanics of convexities, has pointed out that the smaller the area the less pressure will be required to crush a substance. Upon the original occlusal convexities the minimum of force is required for crushing, and it follows, therefore, as facets or concavities are developed, the force required for mastication is greatly increased.

Further, occlusal abrasion¹² is frequently responsible for the loss of balancing inclines, with the introduction of abnormal torque and overstress in the pericementum.

(c) *Faulty Restorations*.—Frequently dental fillings fail to restore the balancing inclines with the consequent establishment of excessive torque production. Again, the balancing inclines are often restored in excess with the disestablishment of equilibrium of the inclined planes and consequent torque-production.

The tendency of clasps and attachments of faulty design to induce pericemental overloading of the horizontal type, on abutment teeth, is so well known as to need no further comment.

(d) *Dental Caries*.—When the balancing inclined planes are lost through dental caries, just as in uneven wear and faulty restorations, great torques are introduced, with horizontal overloading and overstress of the pericementum.

(e) *Excessive Wear*.—Extreme wear¹³ usually results in the loss of occlusal anatomy, the cusps worn flat, and the sulc partly or wholly obliterated. The required masticatory force is much increased with great horizontal overloading and torque production.

(f) *Lack of Occlusal Vents*.—Chapelle¹⁴ has emphasized that the absence of grooves on the occlusal surfaces, to act as sluiceways for food, whether lost through wear, injudicious grinding or faulty restorations greatly increases the stress on the tooth. He has pointed out that the area of the masticating surface should vary with the degree of stress that the tissues will stand, and that this area varies directly

with the extent of pits, fissures and rounded borders allowed for escapes.

(g) *Displacement following Extraction*.—Examples of tooth-movement following extraction, with the introduction of traumatic occlusion and subsequent loosening, are familiar to all dental practitioners. A common example is presented in the Lower Second Molar with extraction of the Lower First Molar. The general direction of stress from the opposing Upper Second Molar is directed obliquely forward. This forward oblique force gives rise to reactions against the Lower First Molar and also on the roots of the Second Molar, the combined effect of which is to cause rotation about some point in the mesio-distal plane. This rotation, however, is prevented so long as the First Molar remains in situ. When the First Molar is extracted the point of support is then transferred to the alveolar crest much lower down, leaving the crown without support at the contact and under stress as before, which brings about a rotational movement forward. The result of this movement is a forward and downward movement of the mesial cusps and a forward and upward movement of the distal cusps. Traumatic occlusion is inaugurated through this latter movement.

(h) *Unaccustomed Mastication of Extremely Hard Foods; Holding of Pipe-stems, Cigarette-holders, etc.; Biting of Threads*.—It is obvious that the periodontal tissues are called upon to bear a much greater stress in the shredding of extremely hard foods, such as grains, seeds and gritty foods than is normal to them in the average civilized community. The holding of pipes and cigarette-holders for long intervals in the same position between the teeth creates very considerable stress in the pericementum and frequently introduces, through overloading, the factor of traumatic occlusion. Thread-biting belongs to the same category.

(2) SECONDARY.—Normal occlusal factor with abnormal periodontal factor; the magnitude of the occlusal force may be normal, but due to inadequate periodontal support overstress is produced.

Examples:

- (a) *Simple Border Atrophy of the Process.*
- (b) *Simplex Periodontitis.*
- (c) *Rarefying Pericementitis Fibrosa.*

Through progressive reduction in the support offered by the alveolar bone in the gingival third zone, consequent on these lesions, there is thereby produced simultaneously an increase in the extra-alveolar lever arm. Provided that the magnitude of the original force remains the same, there is presented a counterpart of the mechanical factors as shown under the primary group, and overstress is induced in the remaining pericementum.

Further, in Rarefying Pericementitis Fibrosa, with the formation of the new tissue in the pericementum and through increase in size of its various perivascular nodules, many principal fibres are severed. The functional conditions of the pericementum as a whole are altered, and the intact fibres are subjected to a very great increase in stress. This overloading of the remaining principal fibres takes place also in pocket formation, where severance of the fibres occurs at the cemental surface.

(3) COMBINED.—Abnormality in both occlusal and periodontal factors; when from a primary traumatic occlusion or other cause, a tooth assumes a position where it receives a still greater occlusal force, due to the already weakened periodontal support, mechanically and frequently pathologically, a doubly damaging situation is created and unless corrected the tooth is soon lost.

Examples:

- (a) *Axial Extrusion.*
- (b) *Lateral Drifting.*
- (c) *Over-eruption.*

Fig. 16.

CLASSIFICATION OF TRAUMATIC OCCLUSIONS — BASED ON RELATIONSHIP OF — OCCLUSAL AND PERIODONTAL FACTORS

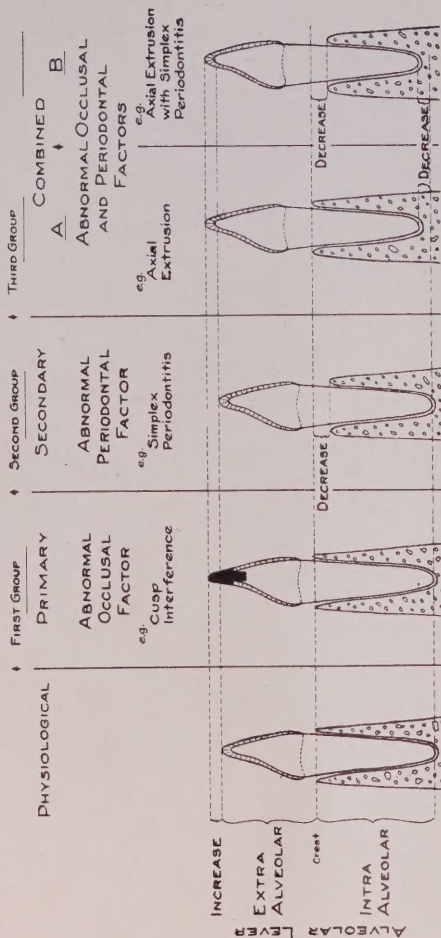


FIG. 16—A CLASSIFICATION OF TRAUMATIC OCCLUSIONS
 This diagram presents the author's classification of traumatic occlusions based on the
 relationship of the occlusal and periodontal factors.

PART II

THE DENTAL WALL OF THE POCKET

(1) CEMENTUM

(a) *Development:*

In man cementum is formed by membranous ossification. When calcification is commencing, a capsule-like investment is formed around the dentine-germ and enamel-organ. This is known as the dental follicle.* The follicle wall, as each portion of the

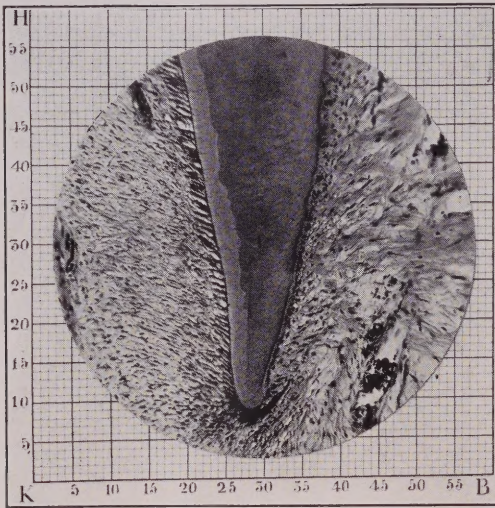


FIG. 17—X100. DEVELOPING ROOT (HUMAN)

This photomicrograph of developing dentine and cementum shows on the left the dentine-papilla with its row of odontoblasts and the forming dentine, and on the right the follicle-wall with its row of cementoblasts and new-formed cementum. As pointed out in the text, as each portion of dentine of the root is formed, it is clothed with a closely adherent vascular membrane, the follicle-wall, which becomes the pericementum on the completion of the cementum.

*The mammalian tooth-germ consists of three parts:

- (1) The enamel-organ, which is derived from the oral epithelium.
- (2) The dentine-organ, derived from the underlying mesoblastic myxomatous tissue of the jaw.
- (3) The dental follicle—also derived from mesoblastic tissue, a source identical with that of the dentine-organ.

dentine of the root is finished, is presented to it as a closely-adherent vascular membrane which, on its inner or dentinal face, exhibits a layer of large cells, known as cementoblasts. Through their agency the cementum is formed, the follicle wall opposite the root persisting as the pericementum. Fig. 17.

(b) *Histology:*

Cementum is a hard tissue which forms the external covering of variable thickness over the roots of the teeth of man and many animals. Overlying the dentine, it begins at the amelo-cemental junction as a thin coverlet, and gradually increasing in thickness, it extends to the apex of the tooth. The cementum is deposited in layers or lamellae, which are thinner towards the neck of the tooth, and consist of a calcified matrix which is sometimes apparently structureless; at others finely granular or globular. Like bone, cementum contains Sharpey's fibres which appear as minute rods running through it at right angles to the lamellae. Through the medium of these fibres the pericementum is attached to the cementum. It is commonly thought that these fibres become calcified by a globular deposition of lime salts in them, as in bone.

Based on the presence of corpuscles or cells, cementum may be divided, as a rule, into two more or less distinct types. The first, the non-cellular, is represented in the cementum of the gingival third and usually part, if not all, of the middle third of the root. Lacunae are practically constant in the apical third and occur there frequently in great numbers. Figs. 18-21.

In a former bulletin the writer¹⁵ described the cellular cementum as follows: "Radiating from the lacunae in all directions are numerous fine channels which branch and subdivide as they extend into the cemental matrix. These are known as canaliculi. They anastomose freely with those from adjoining lacunae, and they also maintain a communication between the lacunae near the surface and the pericementum. In the cemental lacunae are found cells, termed cement-corpuscles, fine projections from which extend into the canaliculi bringing each cemental cell in close relation to a certain zone of matrix over which it has control. The cement-corpuscles communicate freely with one another by union of some of their fine protoplasmic extensions, the other offshoots extending into the canaliculi as delicate processes of variable length. The corpuscles in the lacunae near the surface of the

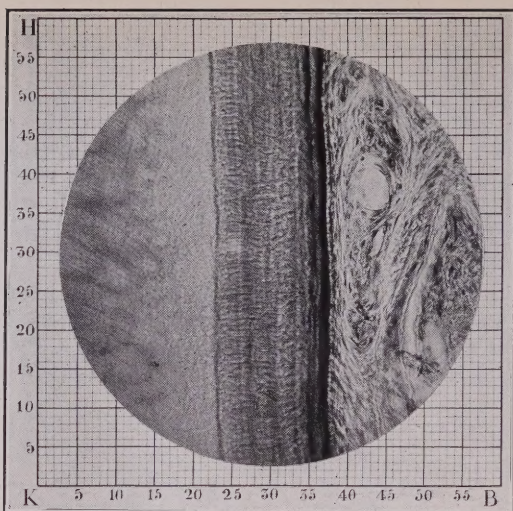


FIG. 18—X200. NON-CELLULAR CEMENTUM (HUMAN)

In this photomicrograph the lamellae or layers of this tissue are to be noted; also the Sharpey's fibres, which appear as minute rods running through it at right angles to the lamellae. Note the absence of lacunae.

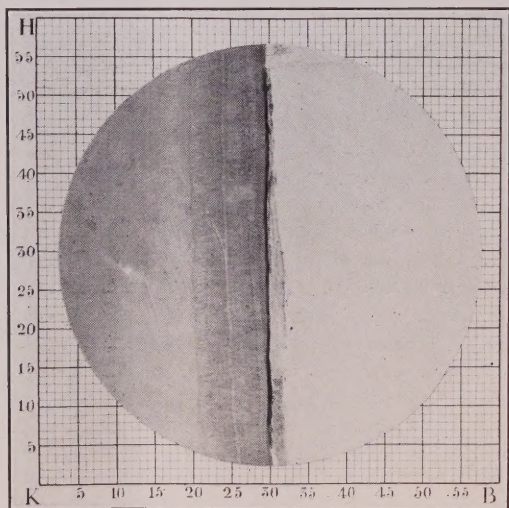


FIG. 19—X200. NON-CELLULAR CEMENTUM (HUMAN)

In this illustration the lamellae or layers of this tissue are shown. Note also the cementum cuticle on the cemental surface.

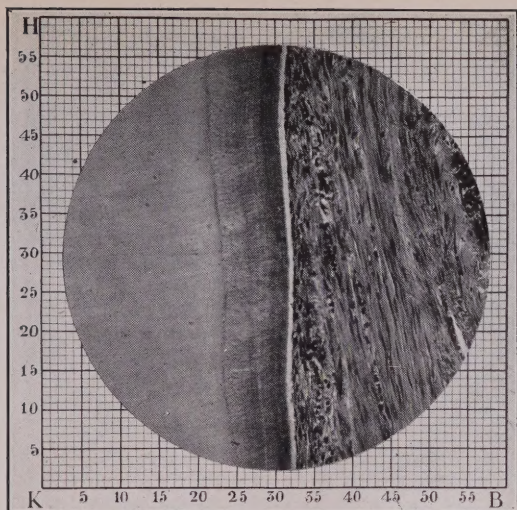


FIG. 20—X200. NON-CELLULAR CEMENTUM (HUMAN)

The lamellae and the Sharpey's fibres running through them at right angles are shown in this photomicrograph.

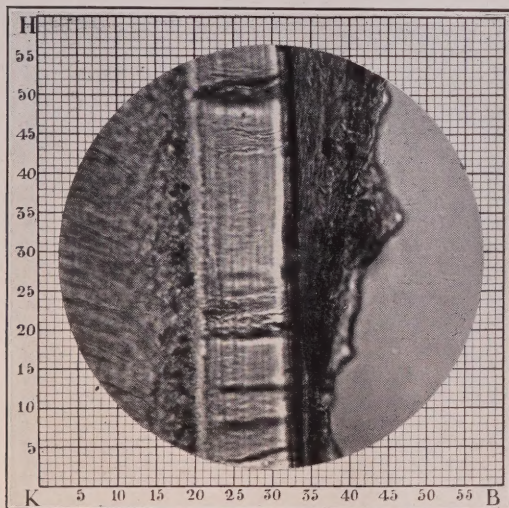


FIG. 21—NON-CELLULAR CEMENTUM (HUMAN)

This illustration is from a ground section and shows plainly the lamellae or layers of this tissue.

cementum, by means of some of their extensions, seem to be joined to protoplasmic bodies in the pericementum. There is, then, in cellular cementum a continuous network of living protoplasm throughout its matrix. The cement-corpuscles and their processes should be considered as being continually bathed in lymph plasma. This plasma circulates throughout the lacunae and canaliculi, which form an inter-communicating network of lymph-spaces similar to that found in bone. The nutrition of the cement-cells and the matrix is thus insured." Figs. 22-23.

The majority of pockets are found upon the cementum of the gingival third, a non-cellular tissue. The teaching of certain writers, notably that of Hartzell,¹⁶ has emphasized that the cementum underlying pockets is comprised of three distinct layers, first, a pitted surface or insertion layer resting on a second, hard layer, which separates it from a third, of fair thickness and containing lacunae and canaliculi. This conception of the structure of cementum gave origin to the current belief that curettement through the second layer would expose the cement corpuscles of the third layer to infection. This teaching is erroneous, and fortunately the fears of cemental infection through over-curettement are ungrounded. The normal cemental matrix of the gingival half of the root, as previously stated, is practically structureless, and as a hard homogeneous band of calcified basis-substance, it constitutes, as a rule, a splendid medium for curettement and soft tissue reattachment.

This histologic fact that the cementum on the surface of which all pockets originate and over which they develop on their progress towards the apex, is free from lacunae, both near the surface as well as in its depths, and consequently devoid of dentinal-cemental passages joining the canal systems of the cellular cementum and dentine, undoubtedly favours in another manner the outcome of these lesions under scientific treatment. Exposure of lacunae and canaliculi with their contained cells and processes to long-standing infective inflammation in the adjacent soft tissues would certainly be a menace to the life of these minute particles of protoplasm. Through their infection and death, the factor of necrotic cellular cementum as a noxious sequel of pocket formation would be introduced, and one which would decidedly render prognosis negative. Fortunately, this condition is non-existent in early pocket formation.

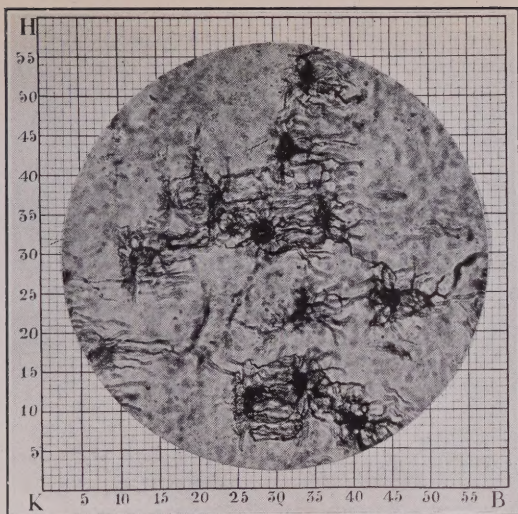


FIG. 22—X530. CELLULAR CEMENTUM (HUMAN)

This illustration shows numerous cemental lacunae in this tissue and the free anastomosis of their many canaliculi, forming an inter-communicating network of lymph-spaces.

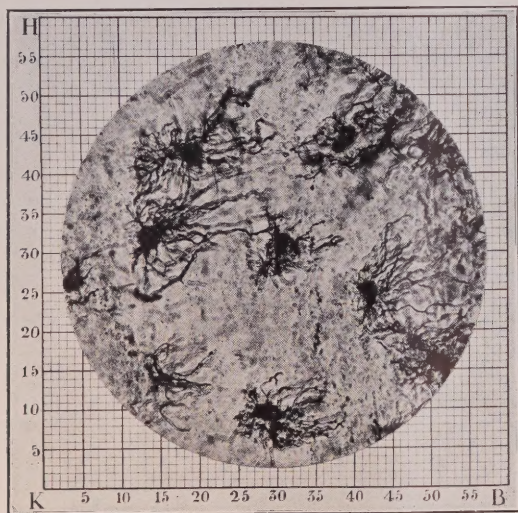


FIG. 23—X530. CELLULAR CEMENTUM (HUMAN)

Here also are shown several lacunae with their canaliculi radiating from them in all directions. Note again the anastomosis of these fine channels.

(c) The Dentinal-Cemental Junction

As stated previously, in the cellular cementum there is an uninterrupted canal system, formed by the anastomosis of the fine canaliculi of neighbouring cemental lacunae. This system is in direct connection with the pericementum through some of the canaliculi of the outer cemental lacunae. Also, as is well known, a continuous network of passages is present in the dentine, established by the interconnection of the very numerous lateral branches given off from the main dental tubules. This tubular system is maintained in direct connection with the dental pulp. These canal systems of the cementum and dentine, according to certain investigators, notably Hopewell-Smith, Black and Noyes, have been considered as completely separated from each other by a zone of dentine and cementum, existing as a dense and nearly structureless band of calcified basis-substance. The findings of the writer,¹⁷ however, are in complete disagreement with this teaching, and have shown that communication between the cementum and dentine does exist. The canaliculi of the cemental lacunae, either directly through union with fine extremities of the dentinal tubules or through connection with small processes of certain spindle-shaped enlargements of the dentinal tubules, or irregular spaces in the granular layer, are in communication with the tubular system of the dentine. Figs. 24-25.

Cahn¹⁸ has observed in ground sections of pyorrhetic teeth peculiar enlarged channels running from the surface of the root directly to the pulp. In Professor Bodecker's opinion, they are of embryonic origin.

The question of the vitality of the non-cellular cementum is purely an academic one, and the author will not burden this treatise with a discussion of it at this time. It is probable that among other major factors its vitality or normality involves the problems of its normal hydrogen ion concentration and the presence of the necessary antibodies, insured by its permeation with the normal tissue fluids. Therefore it is of great importance that the source of these fluids be not greatly interfered with. That pocket formation is bound to introduce certain changes seems logical. The principal point at issue, however, is the effect of these changes on the problem of biological reattachment. There is no evidence histologically of necrosis of the cementum in pocket formation,

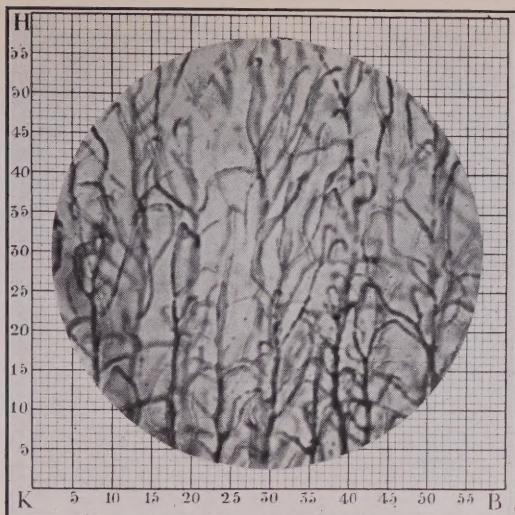


FIG. 24—DENTINAL TUBULES (HUMAN)

In this illustration is shown a typical example of the anastomosis of the fine lateral branches given off from the main tubules. These small twig-like branches anastomose freely providing a continuous network of branches in the dentine.

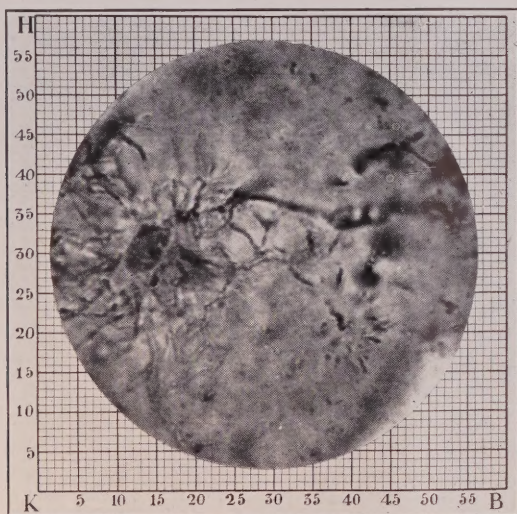


FIG. 25—A DENTINAL-CEMENTAL PASSAGE

This illustration shows that communication between the dentine and the cementum is a histologic fact. On the left may be seen a spindle-shaped enlargement of a dentinal tubule from which a fine process extends to join canaliculi of a cemental lacuna.

and it would appear from the evidence that any changes introduced thereby are not sufficiently great to interfere with reattachment.

The source of the tissue fluids of the non-cellular cementum is probably twofold, viz., dentinal and pericemental. The dentine is supplied directly by the pulp and indirectly through the dentinal-cemental passages from the apical pericementum, and the importance of these communications to the non-cellular cementum is apparent in pocket formation on pulpless teeth or teeth with degenerated pulps.

(d) *Outer Dentine Layer*

In the gingival and middle thirds of the root the larger dentinal tubules frequently fall short of the dentinal-cemental junction. Breaking up into minute branches they become lost as they approach the surface of the dentine. Some tubules, on the other hand, end by joining with terminal branches of others; others again pass into the small interglobular spaces which make up the so-called "granular layer" of Tomes. Tomes (Charles S.) has stated "that nowhere does the structure of the teeth vary in aspect so greatly as in the dentine in the region of the neck." However, in consequence of the tubules stopping short of the cementum, as pointed out by Tomes (Sir John), the matrix substance is present in greater abundance. In many instances it is practically a non-tubular structure, and as a homogeneous band of dentinal matrix it approximates the non-cellular cementum in thickness. This peculiar characteristic of the dentine in this region has a special bearing upon the curettement of the cementum in treatment of the periodontal pocket. Many writers have pointed out that great care must be exercised in this curettement in order to preserve a portion of the cementum as a covering for the dentine. The writer believes that because of the similarity of cementum to the external dentine it is beyond the human sense of touch to determine in curettement when the dentinal-cemental junction is reached, and because of its thinness, and other peculiarities, the cementum must of necessity be frequently removed in its entirety in certain locations. And, fortunately, in this event the outer dentinal layer in this region, where pockets originate and develop, presents to the curetted soft tissues a compatible foundation from the biological standpoint, and a suitable medium for reattachment. Fig. 26.

(e) The Amelo-Cemental Junction

Four relationships of the cementum to the enamel are found at the enamel line:

(1) The cementum slightly overlaps the enamel; Black, Noyes and other investigators state that this relation is found in the majority of cases. Sorrin and Miller¹⁹ report

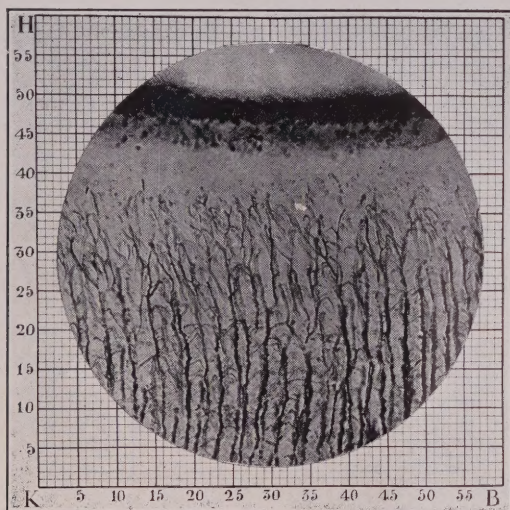


FIG. 26—X400. OUTER DENTINE LAYER (HUMAN)

In the gingival and middle thirds of the root the larger dentinal tubules frequently fall short of the dentinal-cemental junction. This photomicrograph shows an example in which the outer dentine is practically a non-tubular structure.

that it is found in 60% of cases. Choquet found this condition seven times in twenty-nine teeth examined.

(2) The cementum and enamel meet each other without overlapping. Sorrin and Miller report this condition in 30% of cases. Choquet found it nineteen times in twenty-nine teeth examined.

(3) The enamel overlaps the cementum. Sorrin and Miller report this finding in 1% of cases. Choquet found eight cases in the twenty-nine examined.

(4) There is a breach of continuity of these two structures. Choquet found this condition in 27.5 per cent. of his cases examined. Sorrin and Miller report that in 5 to 10 per cent. of cases the enamel and cementum were not in contact. Figs. 27-29.

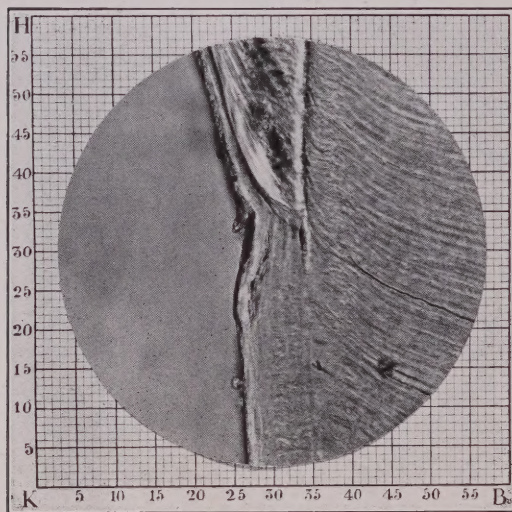


FIG. 27—X265. THE AMELO-CEMENTAL JUNCTION
This photomicrograph shows the cementum overlapping the enamel.

(f) *Thinness of Cementum*

Cementum in man varies considerably in thickness. It has been frequently stated that non-cellular cementum normally measures from 150 to 250 microns. In a general way for most of us it is often difficult to interpret microscopic measurements in a macroscopic way. Thickest scalp hairs have a diameter of 160 microns. Cementum at the neck of a tooth can reasonably be compared in thickness to a scalp hair, as was pointed out by the writer²⁰ some years ago. A realization of this fact makes it obvious that periodontists operating with sharp scalers or curettes must frequently cut through into the dentine. At times this is a necessary

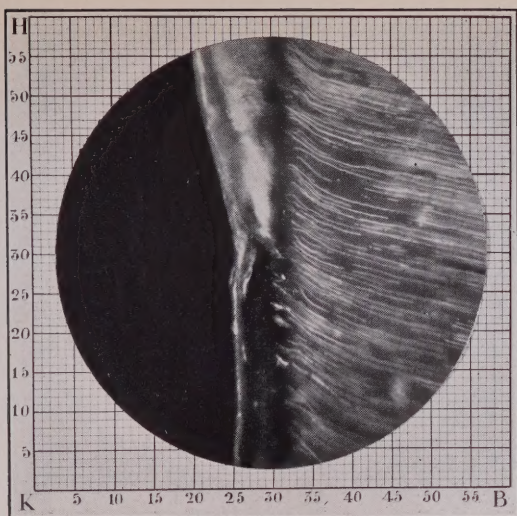


FIG. 28—X265. THE AMELO-CEMENTAL JUNCTION

This is the same field as shown in Fig. 27, photographed with dark-ground illumination.
The cementum overlaps the enamel.

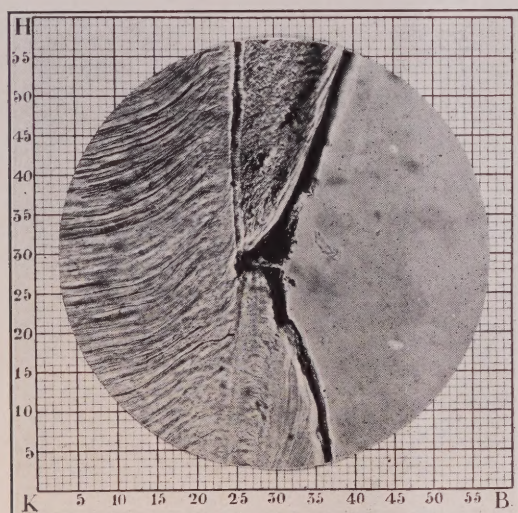


FIG. 29—X265. THE AMELO-CEMENTAL JUNCTION

The cementum and enamel meet without overlapping.

procedure for the successful outcome of pocket-treatment; in any event, unless greatly overdone, this result of curettement does not influence the prognosis unfavourably. Fig. 30.

(g) *Surface Bosselation*

The outermost layer of cementum, as a rule, presents a surface which, under very low magnification, is beset with small rounded eminences or elevations. This condition has been termed by the author bosselation. Tomes (Charles S.) has stated that the outer layer of thick cementum is a glassy film, apparently denser than the underlying portions, and on the surface it is slightly nodular.

(h) *Surface Irregularities*

Certain cemental changes are to be found which profoundly alter the regularity of its surface. Among these are the following:

(1) Excavations.—The regular continuity of the cemental surface is frequently broken by zones of resorption which in many instances involve the outer dentine. The surface of these zones is, as a rule, quite uneven. Figs. 31-32.

(2) Excavations with building.—Examples are frequently noted in which the resorption zones are partially filled with redeposited cementum. Figs. 33-34.

(3) Excavations with spicules.—Occasionally, where large zones of resorption occur side by side, small spikes of cementum remain which project into the surrounding soft tissue. Figs. 35-36.

(4) Cemental Nodules.—Small sessile nodules of cementum are frequently found on the surface of the cementum. Figs. 37-38.

(5) Caries.—While caries of the cementum is less common than that of enamel or dentine, nevertheless it is occasionally found and is a factor, when advanced, in breaking the even outline of the cemental surface. The microorganisms appear to progress along the penetrating fibres of Sharpey. Fig. 39.

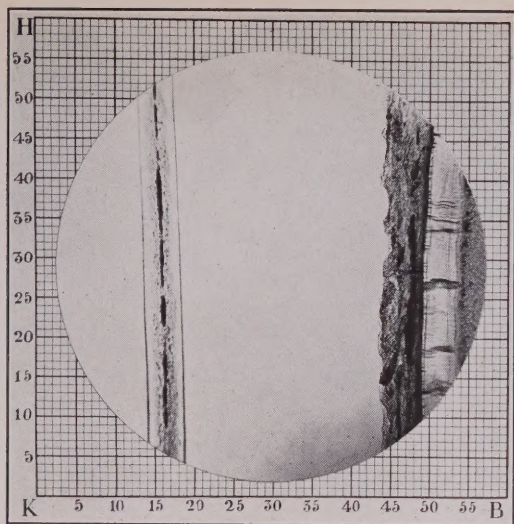


FIG. 30—NON-CELLULAR CEMENTUM AND A HUMAN SCALP HAIR
In this photomicrograph they are approximately of the same thickness. The scalp hair is at the left of the illustration.

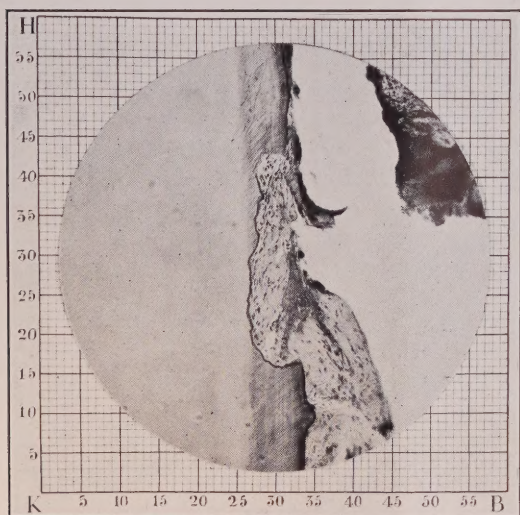


FIG. 31—X100. IRREGULARITIES OF THE CEMENTAL SURFACE—
EXCAVATION (HUMAN)

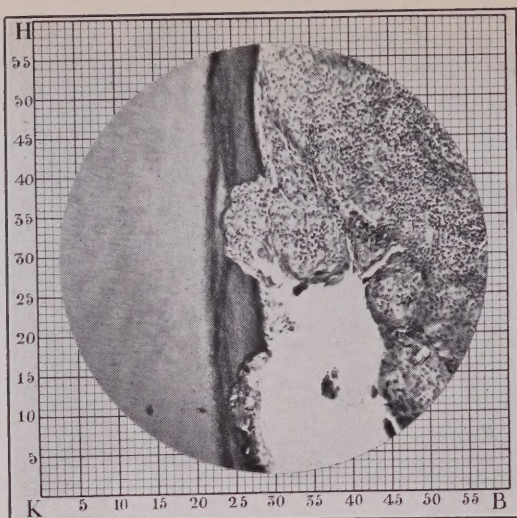


FIG. 32—X100. IRREGULARITIES OF THE CEMENTAL SURFACE—
EXCAVATION (HUMAN)

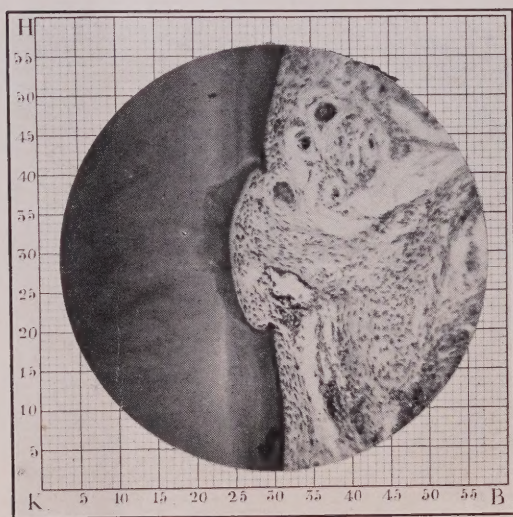


FIG. 33—X100. IRREGULARITIES OF THE CEMENTAL SURFACE—
EXCAVATION WITH CEMENT BUILDING (HUMAN)

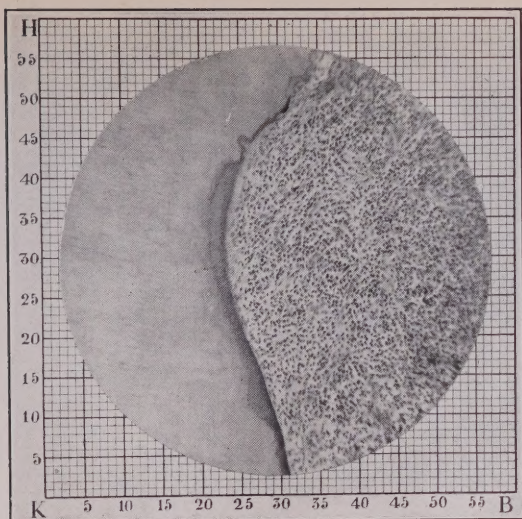


FIG. 34—X100. IRREGULARITIES OF THE CEMENTAL SURFACE—
EXCAVATION WITH CEMENT BUILDING (HUMAN)

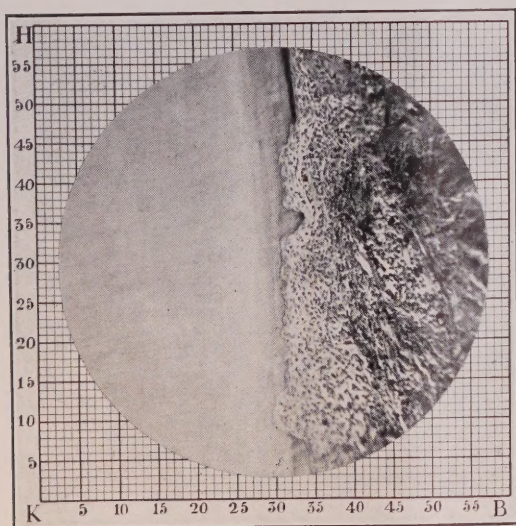


FIG. 35—X100. IRREGULARITIES OF THE CEMENTAL SURFACE—
EXCAVATION WITH SPICULE (HUMAN)

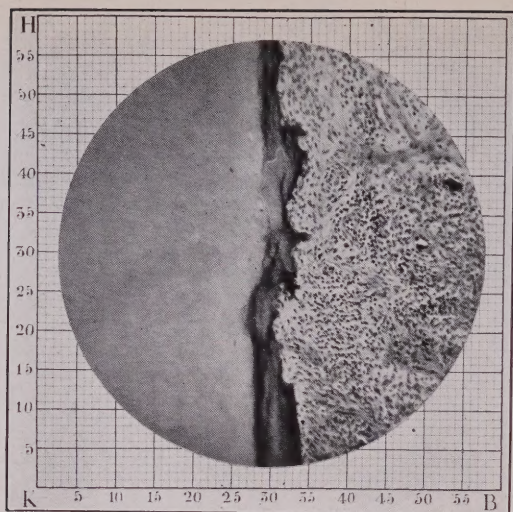


FIG. 36—X100. IRREGULARITIES OF THE CEMENTAL SURFACE—
EXCAVATION WITH SPICULE (HUMAN)

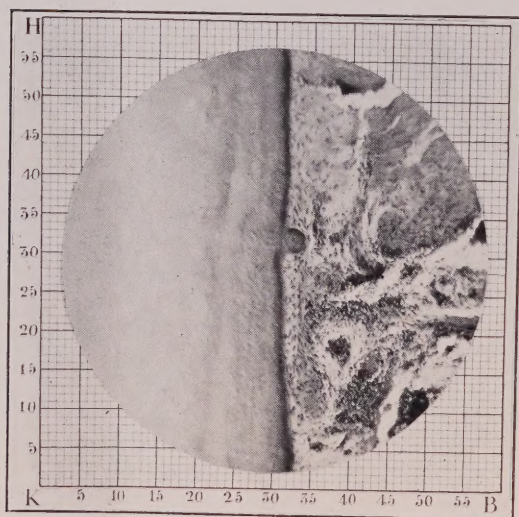


FIG. 37—X100. IRREGULARITIES OF THE CEMENTAL SURFACE—
CEMENTAL NODULE (HUMAN)

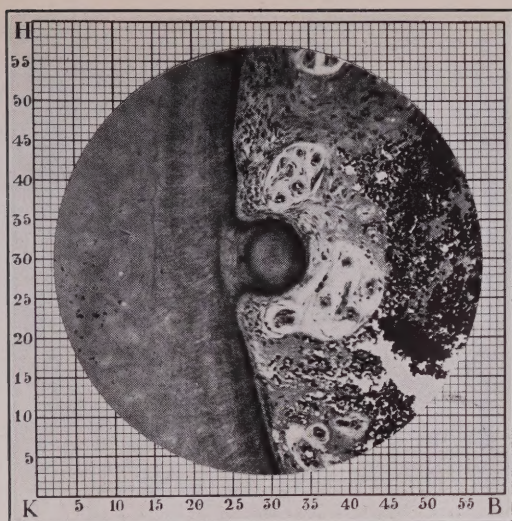


FIG. 38—X100. IRREGULARITIES OF THE CEMENTAL SURFACE—
CEMENTAL NODULE (HUMAN)

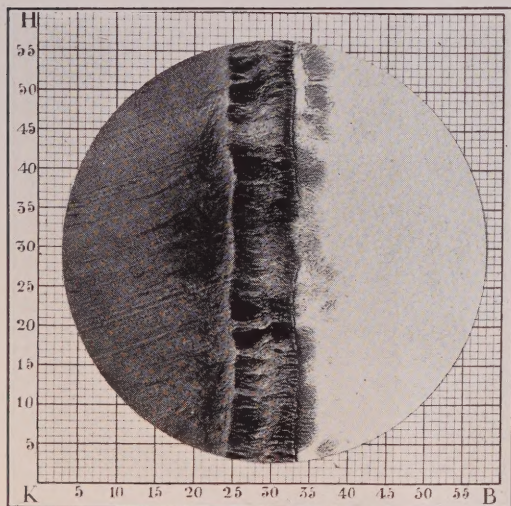


FIG. 39—X200. IRREGULARITIES OF THE CEMENTAL SURFACE—
CARIES OF CEMENTUM (HUMAN)

(2) CEMENTUM CUTICLE

The Cementum Cuticle is a thin homogeneous keratinized layer formed by the crevicular epithelium during its proliferation along the cementum to cover the detached connective tissues. It holds for a time the cementum and the soft tissues in a state of organic union. With separation of the epithelium from the root this translucent pellicle remains, as a rule, firmly adherent to the tooth. It is continuous with that important component of Nasmyth's membrane, the secondary enamel cuticle of Gottlieb, and is its histologic counterpart. As it is formed in the same manner on the surface of the root as on the surface of the crown, Gottlieb has termed this layer in its entirety the "cuticula dentis." Weski confirms the existence of this dental cuticle, and has termed it the "epithelial cuticula;" and further, has divided into a crown-part the "enamel cuticula" and a root-part the "cementum cuticula." The division into enamel and cementum portions, from a topographic standpoint, makes for clarity in periodontal nomenclature and teaching. It would appear, therefore, that this distinction, together with the fact that the term "cuticula dentis," is commonly, though incorrectly used as a synonym for Nasmyth's membrane, presents apparent advantages in the use of an anatomic division of the dental cuticle.

Because of the relationship of the cementum cuticle with Nasmyth's membrane through the outer layer of the latter, and its histological and chemical similarity to it, a brief consideration of Nasmyth's membrane will be of interest at this point.

Alexander Nasmyth,²¹ a Scottish dental surgeon, first called attention to the existence of an exceedingly thin membrane which covers the enamel of the human tooth. Regarding this important structure great difference of opinion has been expressed. It has been described under various names, and is probably best known as "Nasmyth's membrane," or the "enamel cuticle." Certain writers have used the term "cuticula dentis," conspicuous among whom is the name of Waldeyer,²² who described it only as an enamel covering. As he did not know that a cuticle was to be found on the cementum, this term did not accurately delineate his viewpoint.

Among the views held as to the character and origin of Nasmyth's membrane are the following:

- (1) That it was a thin covering of cementum, a conception held by Tomes (Sir John), Tomes (Charles S.), Magitot, Legros, Wedl, Metnitz and Baume.

(2) That it was a product of the ameloblasts,* a viewpoint held by Kolliker, Ebner, Prieswerk, Walkhoff and Miller. Sudduth and Whitman (Mrs. Emily Munn) believed that it was formed by a metamorphosis of the ameloblastic layer.

(3) That it was derived from the external epithelium of the enamel-organ, a view held by Waldeyer, Richter, Röse, Hertz and Bödecker.

(4) That it was formed through the agency of both the ameloblasts and the external epithelium, a viewpoint stated by Hopewell-Smith and Gottlieb.

Hopewell-Smith²³ states: "It is most probable that the cellular layer is derived from the external epithelium and the pellicle or innermost layer from the spent cells of the internal epithelium which have previously undergone a keratinous or somewhat analogous change."

Gottlieb's²⁴ concept, briefly stated, is that first we must distinguish between a primary and secondary enamel cuticle, both together forming Nasmyth's membrane. After completion of the enamel the ameloblasts form a membrane, the primary enamel cuticle about one micron in thickness, and chemically not different from other enamel. Then the ameloblasts, stratum intermedium, and stellate reticulum disappear, and before the eruption of the tooth the outer enamel-epithelium in the zone of eruption is transformed into stratified epithelium with cornification of the inner layers. Upon eruption the stratified outer enamel epithelium unites with the oral epithelium, and as the tooth further erupts this outer enamel epithelium separates from the cornified layer

*Enamel-organ. This part of the mammalian tooth-germ is derived from an inflection of the oral epithelium known as the tooth-band, and to which it long retains a connection by means of its slender cord-like attachment. The young enamel-organ is a bell-shaped structure, formed by the broadening of the end of the ectodermic epithelial ingrowth, and it caps the mesodermic elevation termed the dental papilla or dentine-organ. This, as pulp tissue, partially persists as a permanent structure. When fully developed, proceeding from without inwards, the enamel-organ consists of four layers, viz:—an external epithelium, a stellate reticulum, a stratum intermedium, and an internal epithelium, the external and internal layers being continuous at its base. The cells of the internal layer are known as ameloblasts, and through their active agency the enamel is produced.

or secondary enamel cuticle. This secondary enamel cuticle is united with the primary enamel cuticle, and both together form Nasmyth's membrane, a cuticle about five microns in thickness.

Further, the base of the gingival crevice is located at any time at the deepest point of separation. The band around the enamel formed by the epithelial attachment first extends to the amelo-cemental junction, in other words, to the full extent of the outer enamel epithelium. When the base of the crevice arrives at the amelo-cemental junction the epithelial attachment has already started downwards on the cementum. The layers of epithelium towards the root cornify in the same manner as the outer epithelium in the formation of the secondary enamel cuticle, and on separation there remains on the tooth a cornified membrane.

James and Counsell,²⁵ in an excellent work have recently called attention to the formation of this keratinized layer on the root-surface. They state: "As the condition advances, a proliferation of the epithelium along the cement is seen, a change which has been recognized by other workers. The cellular elements retain the characters of the subgingival epithelium. The very firm attachment to the cement by means of a newly-formed keratinized layer, continuous with that on the enamel, is a feature of much significance." Referring to the pocket they state further: "It is lined on the tooth aspect by the keratinized layer, cells attached undergoing atrophy, and on the gingival aspect by the main cellular part of the subgingival epithelium."

Lewis²⁶ also refers to this layer and states that its function appears to be that of binding down the epithelium to the cementum. He writes as follows: "Normally the free gingivae are attached to the cementum by means of epithelium, and in a large number of sections examined no hint is given as to the precise way in which the two tissues are cemented. Numbers of sections, however, clearly show the presence of an 'intermediary substance' which appears to be a highly resistant keratinized product of those epithelial cells which lie against the cemental surface. It consists of a hyaline layer lying between the cementum and the epithelium, which tends to become thinner as it approaches the end of the 'epithelial process' as this advances down the tooth-root. It clings very tenaciously to the cemental wall, and is firmly attached to the epithelium which will itself tear rather than part from this substance."

Orban and Kohler,²⁷ in summing up their findings in pocket formation, have stated that the epithelium is separated from the tooth in the following different ways:

(1) A smooth separation of the epithelium occurs without previous changes of the epithelial surface.

(2) A transformation of the superficial epithelial cells sets in before the separation, whereby, in humans and in some animal-species, a homogeneous cuticula dentis is formed which remains on the tooth.

(3) In other cases a degeneration of the surface epithelium may occur without transformation into a cuticula dentis; thereby a membrane which is formed by these degeneration products may also adhere to the tooth surface.

(4) There occurs, lastly, a degeneration of the surface enamel-epithelium, with apparently complete destruction of these parts, in which case this destruction represents the separation of the epithelium from the tooth surface. This type is the rule in dogs.

As was shown by the writer in an earlier treatise, certain granulomata present, as a striking feature of the microscopic picture, epithelial strands which extend everywhere throughout the lesion, and seem in many instances to manifest a definite tendency to encircle minute zones of connective tissue. These strands are formed through proliferation of the pericemental epithelial rests, and are also seen growing along the surface of the cementum. Gottlieb was the first investigator to show that as the pocket-epithelium forms a horn-layer on the cementum, the granuloma-epithelium forms a horn-layer on the root tip in exactly the same manner. This was later confirmed by Lund.

Granulomata, as is well known, are commonly found in the bifurcation of the roots of molars and bicuspid; and, as a rule, these lesions are associated with Chronic Periodontitis. The writer has observed many splendid examples where the epithelium proliferating along the cementum has produced a well-formed and very definite "cementum cuticle."

The dental cuticle has long been known for its singular power of resistance to reagents, manifested chiefly by its insolubility in strong acids and alkalis. Some of its chemical qualities, according to Ebner,²⁸ are as follows:

(1) It is unchanged by soaking in water.

(2) It does not dissolve in boiling water, strong acetic, hydrochloric, sulphuric and nitric acids.

(3) It remains unchanged in caustic ammonia.

(4) Boiled in caustic potash and soda it becomes white, somewhat loosened, but remains hanging together.

(5) It burns with an ammonia odour and gives a calcareous spongy ash.

Waldeyer considered that its chemical reactions placed it in the class of cornified membranes, and Tomes (Charles S.) stated that when burnt it gives off a smell like that of burning horn. Urban and Kohler point out that the only half reliable test, chemically, for horn is its insolubility in acids and alkalis, and that the dental cuticle stands this test.

In the light of the present knowledge of the dental cuticle there can be little doubt that one of the main functions of this much neglected structure is a protective one. As new light was shed on its origin, structure and characteristics, its importance in this relation to the underlying dental tissues was realized. Paul,²⁹ in 1894 in a paper on Nasmyth's membrane, stated: "It seems reasonable to suppose that enamel devoid of its protection could hardly compete with that which is shielded by it." He further says: "May it not protect the enamel from those chemical changes constantly at work in the mouth?" Later, Hopewell-Smith,³⁰ in discussing Nasmyth's membrane, has stated: "Its position on the circumference on the exposed portions of the teeth, its keratinous character, its resistance to acid and alkaline solutions, its comparative toughness, all intrinsically act as a defence to the underlying parts." Gottlieb, in referring to the dental cuticle, in his work on the "Etiology and Prophylaxis of Tooth-Caries," has concluded that "the immunity against caries depends on the degree of the cornification of the 'cuticula dentis,' and especially of the lamellae." While few direct references have been made by investigators concerning the protection afforded the cementum by its cuticle, it is obvious that the cementum shares with the enamel this immunity against caries when thus defended.

At this point the writer wishes to emphasize a most important feature—and one which evidently has been overlooked—of this protection of the cementum from extrinsic harmful influences by the cementum-cuticle, *viz.*, its bearing on the treatment of the periodontal pocket. It seems reasonable that the cementum,

protected by a cuticle singularly resistant to powerful acids and alkalis and laid down prior to pyogenic infection, as a rule, is little influenced by the various components of the fluids of the pocket, including pus.

No teaching has done more to discourage a hope for reattachment, and the furtherance of methods in periodontal therapeutics based on a belief in reattachment, and which aim to produce it, than the tenets enunciated by Black (A. D.). These are based on the dictum of Black (G. V.)³¹ that "Suppurative detachments of the periodontal membrane are permanent detachments." This theory of so-called pus-soaked cementum, *i.e.*, the saturation of the cementum, in pocket-formation, with the products of suppuration, and the postulate that there is no prospect of reattachment to such cementum, has been widely taught and accepted. The writer states that this teaching is untenable in the light of present findings, and therefore should be discarded. The author's concept is founded on evidence that reattachment is biologically possible—evidence based on observations and experiments, demonstrated clinically and histologically, and therefore satisfying, partly at least, the requirements of a truly scientific method. It seems rational to the author that the protection given to the cementum by its cuticle through its peculiar physical and chemical characteristics, must be included in those factors which collectively have made this reattachment possible. Figs. 40-50.

(3) CALCIFIC DEPOSITS

Calcific deposits do not extend, as a rule, to the base of the pocket. Usually they are formed upon the cementum cuticle, and with loosening of the deposits from the tooth-surface in preparation of specimens the cuticle frequently adheres to the calculus. As stated in a previous bulletin, in pocket formation, the soft tissues invariably are detached from the cemental surface in advance of the deposition of calculus, which therefore, as commonly held, is not a primary agent in pocket extension. It is both a mechanical and infective irritant, and in the adjacent soft tissues there is usually to be found a rich capillary bed. Figs. 51-54.

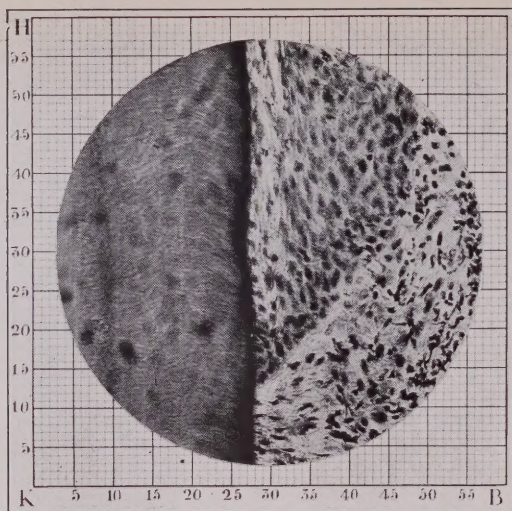


FIG. 40—EPITHELIAL ATTACHMENT (HUMAN)

This microphotograph shows a wedge-shaped group of epithelial cells attached to the cementum. Note that a cementum cuticle extending almost to the base of the attachment has been formed.

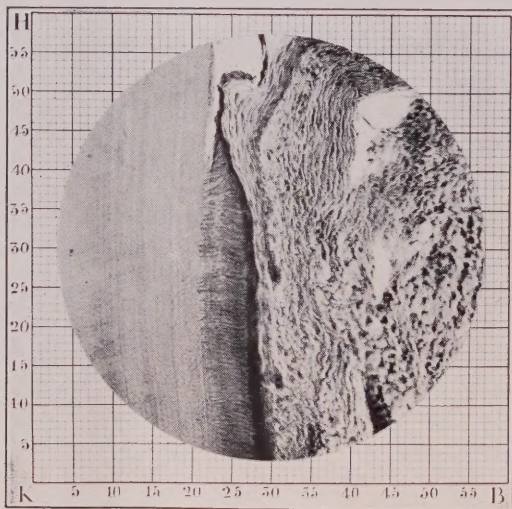


FIG. 41—X265. EPITHELIAL ATTACHMENT (HUMAN)

Note the long, narrow band of epithelium extending along the cementum. A cementum cuticle which is continuous with Nasmyth's membrane has been formed by the upper portion of the epithelial attachment.



FIG. 42—X265. THE CEMENTUM CUTICLE AT THE AMELO-CEMENTAL JUNCTION (HUMAN)
 Showing the cementum cuticle continuous with the outer component of Nasmyth's membrane, the secondary enamel cuticle of Gottlieb.

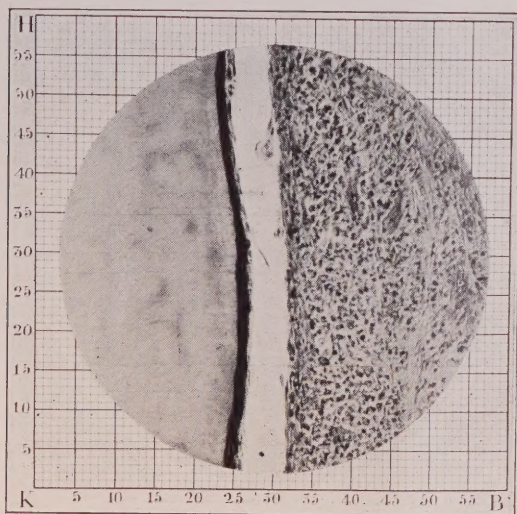


FIG. 43—X265. CEMENTUM CUTICLE (HUMAN)
 In this illustration there is presented a striking example of pocket formation in which, after separation of the epithelium from the tooth, a homogeneous keratinized layer—the cementum cuticle—has remained adherent to the cemental surface.

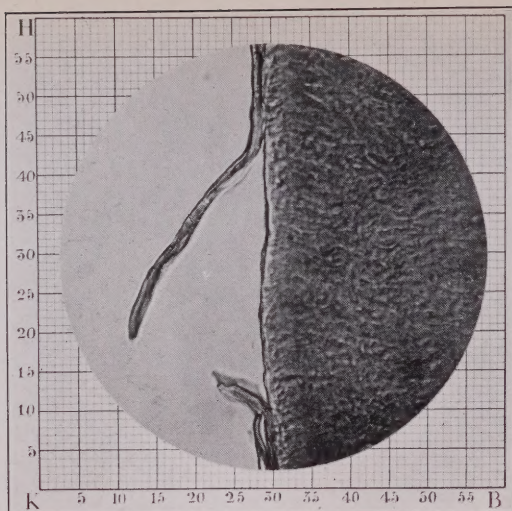


FIG. 44—X600. CEMENTUM CUTICLE (HUMAN)

This high magnification shows the keratinized layer, the cementum cuticle, broken and lifted from the cemental surface.

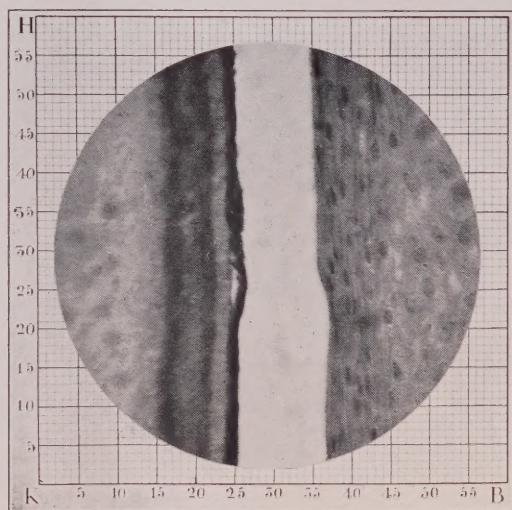


FIG. 45—X400. CEMENTUM CUTICLE (HUMAN)

In this photomicrograph the cementum cuticle is plainly shown on the surface of the cementum. A small portion, near the centre of the illustration, has been lifted from the tooth surface.

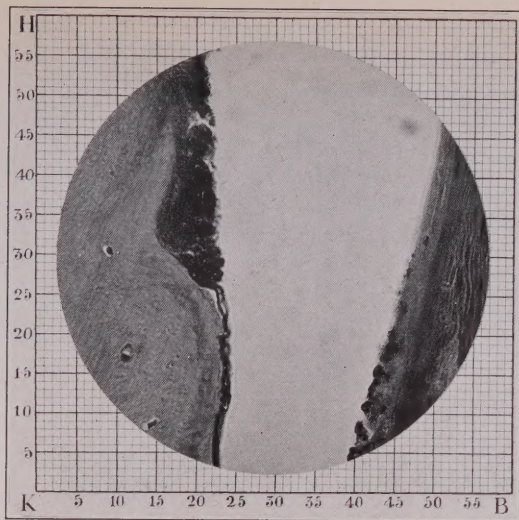


FIG. 46—X400. CEMENTUM CUTICLE (SHEEP)

The keratinized or horn layer is demonstrated passing under a small mass of calculus.

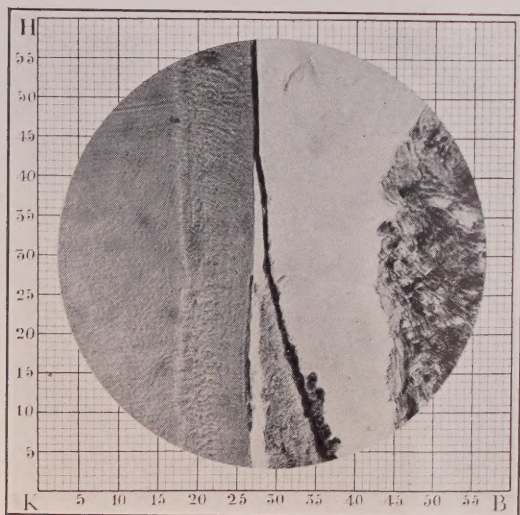


FIG. 47—X265. CEMENTUM CUTICLE (HUMAN)

In this illustration the keratinized or horn-layer is demonstrated passing from the cemental surface, to which it is firmly adherent, over a nodule of calculus. It is obvious that in this case tissue separation and calculus deposition have preceded cuticle formation.

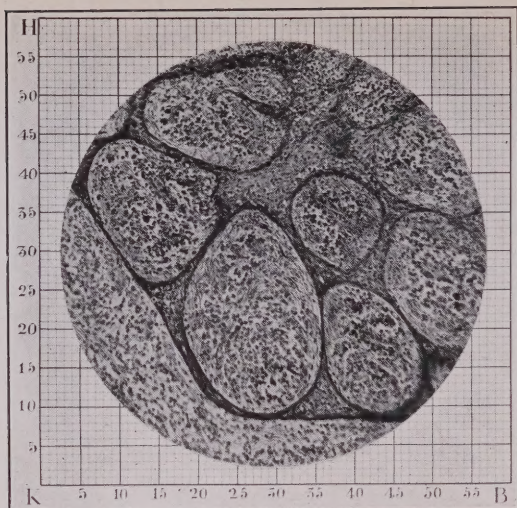


FIG. 48—X100. EPITHELIATED GRANULOMA (HUMAN)

In this illustration there is presented a striking example of the extension of epithelial strands throughout the granuloma.

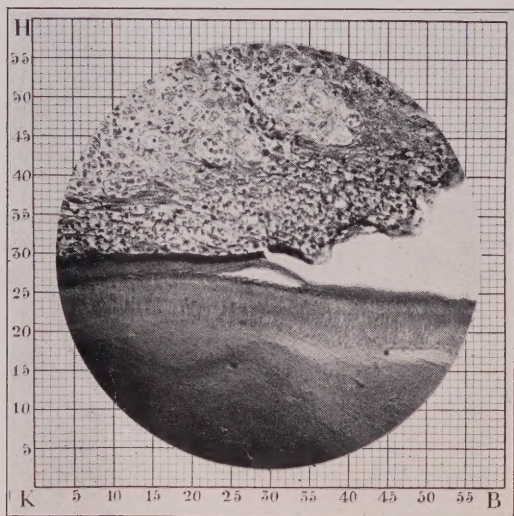


FIG. 49—X200. CEMENTUM CUTICLE (HUMAN)

In this photomicrograph of a bifurcation-granuloma the epithelium proliferating along the cementum has produced a well-formed horn-layer or cuticle.

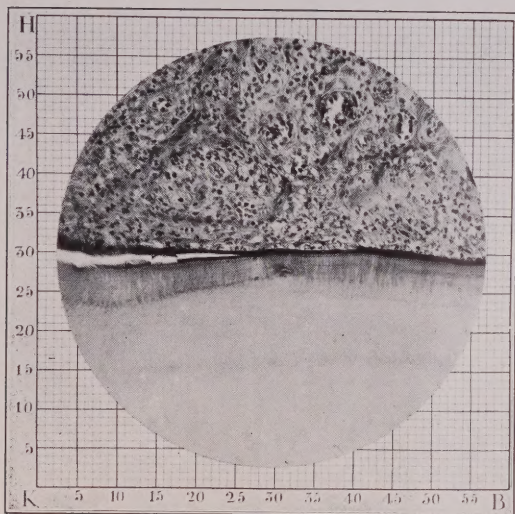


FIG. 50—X200. CEMENTUM CUTICLE (HUMAN)

Here is shown, as in Fig. 49, a splendid example of cementum cuticle formed by the epithelium in a granuloma in a molar-bifurcation.

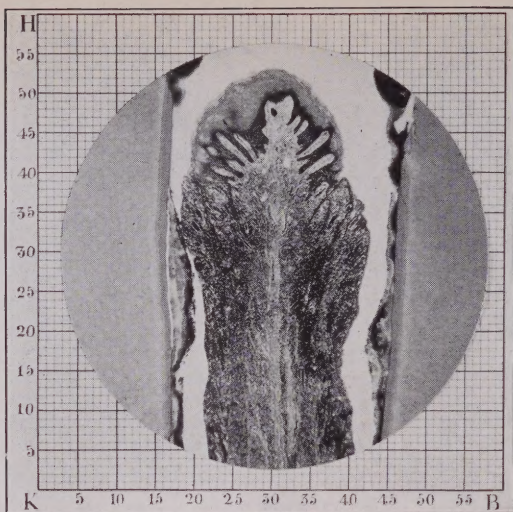


FIG. 51—X50. CALCULUS ON CENTRAL INCISORS (HUMAN)

This photomicrograph of a mesio-distal section of central incisors, and the septal gingiva, shows large masses of calculus under the soft tissues and adherent to the tooth surface. Note the intense inflammatory reactions in the soft tissues adjacent to the calcific deposits.

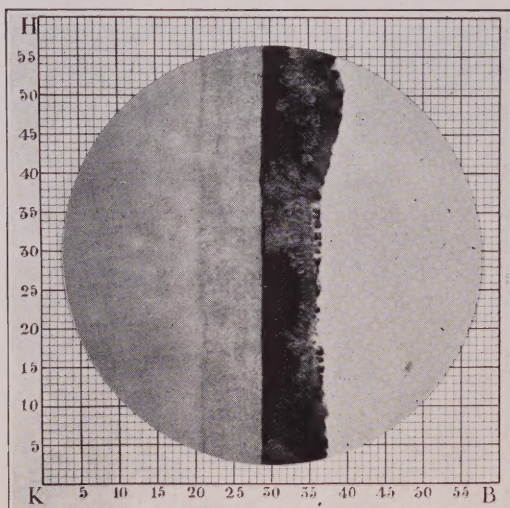


FIG. 52—X200. CALCULUS ON CEMENTAL SURFACE (HUMAN)

In this illustration the calculus and the cementum are approximately of the same thickness.

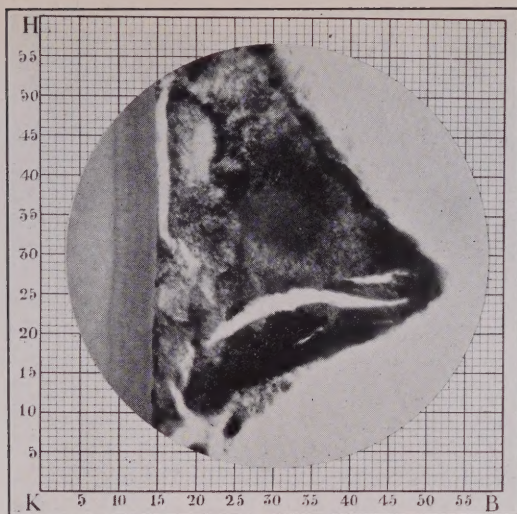


FIG. 53—X200. LARGE SHARP-POINTED NODULE OF CALCULUS ON THE CEMENTUM (HUMAN)

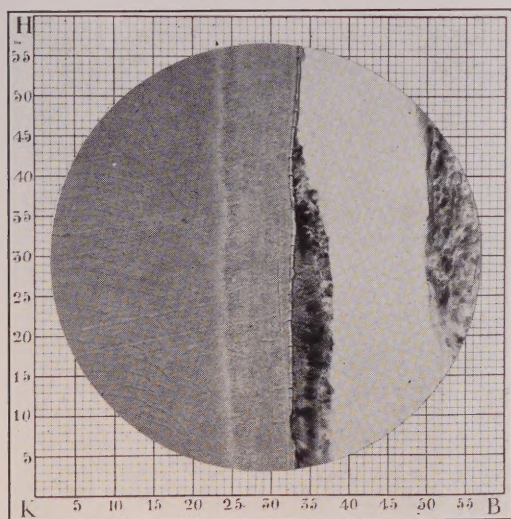


FIG. 54—X200. CALCULUS ATTACHED TO CEMENTUM CUTICLE
Note the peculiar segmented appearance of the cuticle.

THE PERIODONTAL WALL OF THE POCKET

The wall of the pocket formed by the soft tissues is covered, as a rule, with epithelium to its deepest portion.

The gingival margin is created when, during the projection of the tip of the tooth into the oral cavity, in eruption, the outer enamel-epithelium joins with the oral epithelium. As Gottlieb has shown, with further eruption the epithelial attachment becomes separated from the enamel, and the base of the crevice or pocket is at any time denoted by the deepest point of separation. When the crevice-base has reached the enamel-line the epithelial attachment has already advanced apically and is found upon the cementum. And when in pocket formation the base is to be found upon the cementum the epithelium has further proliferated in advance along the cemental surface. In other words, with severance of the principal fibres from the cementum, the crevicular epithelium proliferates and extends apically to cover the detached connective tissues, at the same time maintaining organic connection with the cementum. When separation occurs, with or without cuticle formation, the pocket is created and, as stated previously, is lined to its deepest part on the soft tissue side with epithelium.

From a survey of the literature it would appear that Hecker³² was one of the earliest periodontal investigators to call attention to this epithelial lining of the soft tissues in the pocket. As a further point of interest the statement of Hartzell³³ that "new epithelium will not extend itself deeper into a pyorrhea pocket than the normal depth of its original gingival crevice" finds no support in our microscopic findings.

The periodontal pocket is comparable in many ways to an infected tonsillar crypt. The epithelial lining of the pocket is usually much thinner than that of the gingival mucosa. In certain zones actual small breaks in the epithelial continuity are to be noted. Both along the pocket-wall and at its base, through proliferation long finger-like epithelial processes frequently extend into the underlying connective tissue.

The sub-epithelial connective tissue from the gingival margin to the pocket-base, and for a considerable distance beyond, presents constantly a marked cellular infiltration, and in the later stages chiefly of the plasma cell type. In mature cases, towards the gingival margin, remnants of the original fibre-bundles are to be

noted, completely surrounded by dense masses of inflammatory cells. Lymphocytes, mononuclear wandering cells and young fibroblasts are also to be seen in these zones, which extend in projections, often wedge-shaped, between the fibrous tissue bundles above the crest of the alveolar bone. Hyaline droplets that have been developed in the cytoplasm of plasma cells are also to be seen persisting in the inflammatory zones. They are often called "Russell's fuchsin bodies." In the later stages the fibrous tissue mat has been reduced to a few parallel strands of fibres which separate enormous members of inflammatory cells. Extension of the cellular infiltration into medullary spaces of the alveolar bone is constant. It is noteworthy, on the other hand, that in the pericementum these marked cellular reactions are, as a rule, absent or slight except in advanced conditions. James and Counsell³⁴ state that "a study of the extension of cellular infiltration provides little evidence in support of the view that lymphatic vessels from the corium pass into the periodontal membrane."

The presence of pus in the periodontal pocket is occasioned by the superimposition of secondary inflammatory processes, pyogenic infections, upon the primary non-suppurative inflammatory process. These suppurative inflammations are initiated at various sites along the pocket wall where, through injury, extreme thinness or breaks, the epithelium has afforded portals of entry for pyogenic micro-organisms. In these zones many polymorphonuclear leucocytes are present.

As a rule there is to be seen in the sub-epithelial connective tissue a rich capillary bed or network which is particularly conspicuous in those regions adjacent to masses of calculus upon the cementum. Occasionally small hemorrhages are noted as well.

Supported by the remaining sound fibrous tissue there is to be found, therefore, a layer of infective granulation tissue varying in thickness, and covered by epithelium. The removal of this granulation tissue with its epithelium, by special periodontal curettes, constitutes one of the fundamentals of pocket therapeutics when reattachment of the soft tissues with the tooth is the objective. Conditions are found, however, where through thinness of the normal tissues, the formation of the granulation layer has resulted in almost complete destruction of the fibrous connective tissue, and the fibrous residue presents an inadequate foundation for reattachment following curettement.

THE PERIODONTAL POCKET AND FOCAL INFECTION

A focus is an infected site; whether the bacteria leave that focus either by the blood-stream or by the lymphatics to reach distant sites of secondary infection determines whether the process of focal infection is going on or not. Billings³⁵ has defined a focus of infection as a "circumscribed area of tissue infected with pathogenic micro-organisms." Such infected foci should include only those in which a demonstrable zone of reaction is present and do not include the normal presence of bacteria in the superficial layers of the mucous membrane, between the epithelial cells and in the orifices of small mucous glands such as Bloomfield³⁶ has suggested.

Holman³⁷ has defined the principle of focal infection as "the process of infection from an established infected focus and the secondary infection of other parts." He states further that "such an infected focus is not simply the site of the portal of entrance in bacterial invasion such as occurs in all infectious diseases, but is a local well-established infection capable of permitting the passage of its contained germs, from time to time, into the circulation."

The following factors interfere with the establishment of the process of focal infection:

- (1) An impermeable fibrous capsule.
- (2) A poor capillary response due to the relative inactivity of the bacteria in the focus.
- (3) The presence of high bactericidal substances in the blood-serum.
- (4) Perfect immobility of the part, which favours the healing process and lessens the opportunity for mechanical passage of bacteria into the blood-stream.

Recently Holman³⁸ has stated that "the factors determining the invasion of bacteria from an infected focus are largely dependent on the local circulation about and in the focus, and the relative quiescence or movement of the tissues. Dilatation of capillaries tends to facilitate such an invasion but sluggish circulation may permit the more invasive types of microbes, such as streptococci, to grow through or to produce local thrombi in the smaller vessels. The survival of these invading bacteria depends on their virulence (rate of growth) and on the inherent ability of the endothelial cells

in a given organ to destroy them. The amount of damage resulting from virulent bacterial infections depends both on the pathogenicity of the parasite and on the resisting mechanism of the host."

As pointed out recently by the writer,³⁹ the following are conditions which make a periodontal pocket a site for focal infection:

(1) The periodontal pocket is an infected focus, *i.e.*, it is an abnormal site of bacterial implantation with definite evidence of reaction on the part of the soft tissues. The thin epithelial layer, or actual breaks in the epithelium, as shown in a work⁴⁰ some years ago, makes this region particularly liable to direct infection from the oral cavity. Further, the close adaptation of the soft tissues to the tooth interferes with drainage and causes stasis, and ideal cultural conditions for bacterial growth are always present.

(2) Factors exist which favour the passage of bacteria into the blood-stream or surrounding tissues, *viz.*:

(a) The presence of a rich capillary bed, with their thin walls evidenced clinically by the ease with which bleeding takes place under certain conditions, *e.g.*, probing, scaling. This capillary bed renders the passage of bacteria into the blood-stream particularly simple.

(b) The presence of irritating agents, such as calculus, which produce a continued capillary response in the adjacent soft tissues.

(c) The mobility of the tooth in its alveolus, under occlusal stress as in mastication, swallowing and nervous habits, which interferes with the healing process. This is true of mobility for every infected region of the body. This factor of tooth-mobility is constant under normal occlusal conditions and greatly exaggerated in traumatic occlusion. Figs. 55-79.

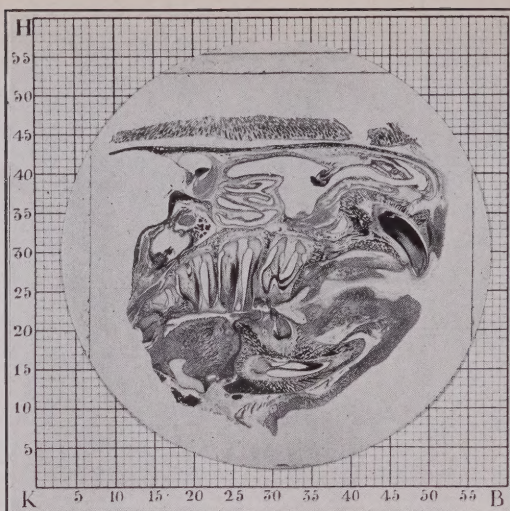


FIG. 55—X3. RABBIT'S HEAD

This section of the head of a young rabbit shows teeth in various stages of eruption. The large chisel-like incisor, in the upper denture, has not yet penetrated the oral epithelium. Behind the diastema in the upper denture a molar crown has just broken through into the oral cavity. Distal to this tooth another molar is to be seen, the cusps of which are some little distance from the oral epithelium.

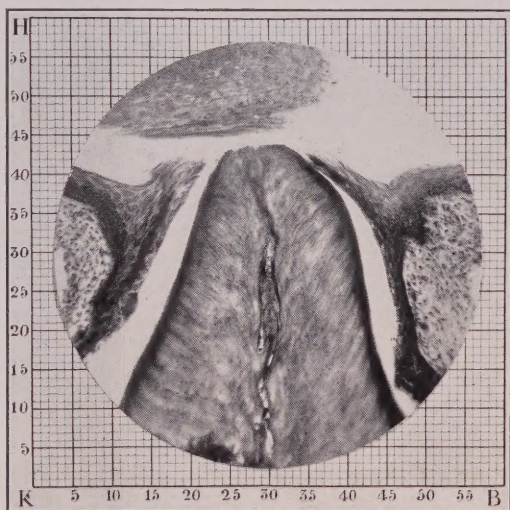


FIG. 56—X100. ERUPTING TOOTH OF RABBIT

This illustration shows the tooth projecting into the oral cavity, with the outer enamel epithelium uniting with the oral epithelium to form the gingival margin.

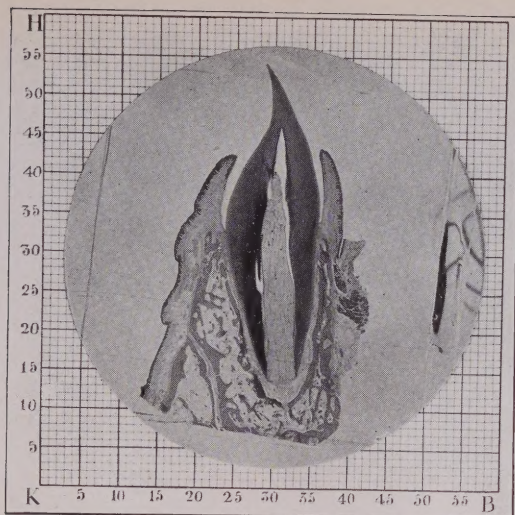


FIG. 57—X3. ERUPTING TOOTH (HUMAN)

The subgingival spaces shown in this illustration are not gingival crevices or pockets; prior to decalcification of the specimen they were occupied by the enamel. The base of the gingival crevice, near the gingival margin, is situated on the enamel midway between the enamel line and the incisal edge.

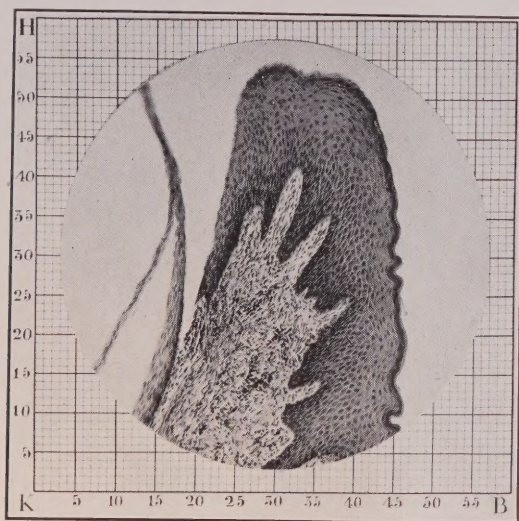


FIG. 58—X100. EARLY GINGIVAL CREVICE (HUMAN)

Upon eruption the stratified outer enamel epithelium unites, as a rule, with the oral epithelium. In this illustration of the gingival tissues of an erupting tooth is to be noted the base of the gingival crevice formed by the amelo-gingival angle. In this instance it is situated on the enamel midway between the enamel-line and the incisal edge. A small break separates the oral epithelium from the outer enamel epithelium, and beneath it is to be seen a zone of small cell infiltration.

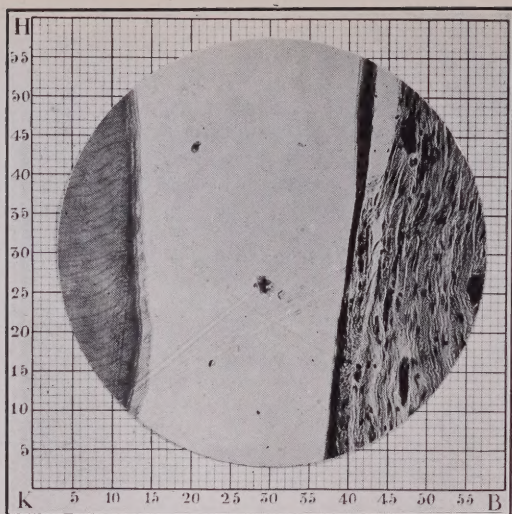


FIG. 59—X200. OUTER ENAMEL EPITHELIUM (HUMAN)

The band across the enamel formed by the epithelial attachment first extends to the amelocemental junction, in other words, to the full extent of the outer enamel epithelium. In this photomicrograph of the same erupting tooth as described in Fig. 58 the tissue-relations between the gingival crevice and the enamel-line are shown. Note the space left by the enamel after decalcification, and the outer enamel epithelium which, prior to decalcification, was united to both the enamel and the gingival connective tissue.

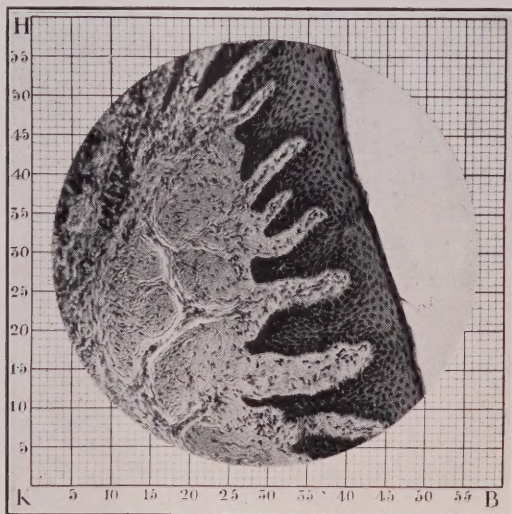


FIG. 60—X132. GINGIVAL MUCOSA (HUMAN)

This illustration shows the oral epithelium—stratified squamous, which covers the marginal and cemental gingivae. Note the connective-tissue papillae which extend into the epithelium.

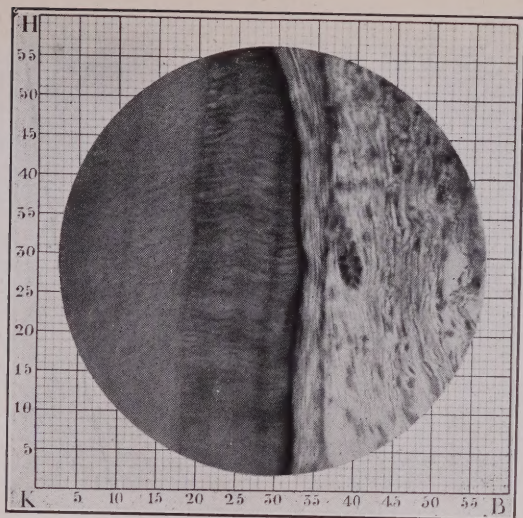


FIG. 61—X400. EPITHELIAL CELL-REST UNITING WITH ATTACHMENT (HUMAN)

This photomicrograph shows an epithelial cord or rest in the gingival tissues near the base of the crevice, the cells of which are proliferating and fusing with the epithelial attachment. (Human.)

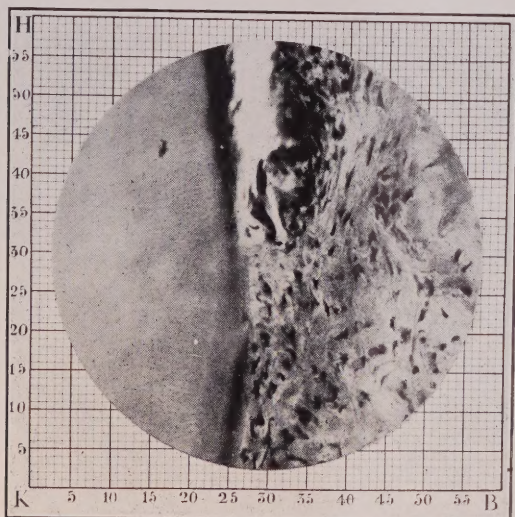


FIG. 62—X400. POCKET FORMATION (HUMAN)

This photomicrograph shows the base of a deep periodontal pocket. Epithelium covers the soft tissue wall. Immediately beneath the pocket-base there is to be noted in the connective tissue a small wedge-shaped zone in which the fibres and cells have lost their staining capacity and have become somewhat indistinct. It is evident that here the tissues have undergone a definite chemical change. This condition in many instances precedes detachment of the fibres from the cementum.

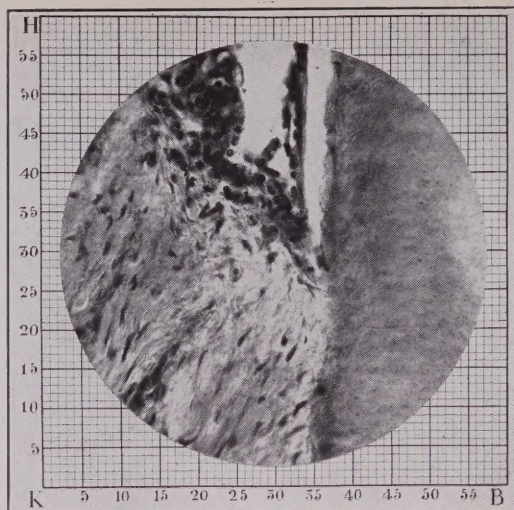


FIG. 63—X400. POCKET FORMATION (HUMAN)

This photomicrograph shows the base of another periodontal pocket. Note the epithelium covering the soft tissues to the pocket-base, also the cementum cuticle which has been separated from the tooth in the preparation of the section. Here again is presented a fairly large wedge-shaped zone in the connective tissue beneath the pocket-base, in which the cells and fibres are poorly defined. This change evidently precedes actual stripping of the principal fibres from the tooth.

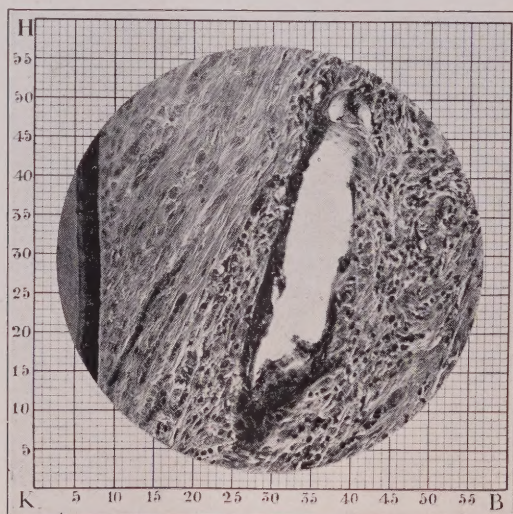


FIG. 64—X200. GINGIVAL CYST (SHEEP)

Here is shown in the connective tissue of the gingiva, a small cavity lined with epithelium.

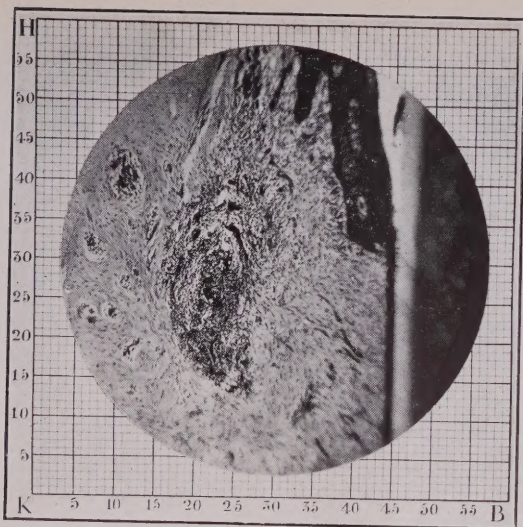


FIG. 65—X80. INTENSE CELLULAR INFILTRATION IN GINGIVA
(SHEEP)

In the centre of this zone of inflammatory reaction a small foreign body may be noted.
This is probably a thistle or a small thorn.

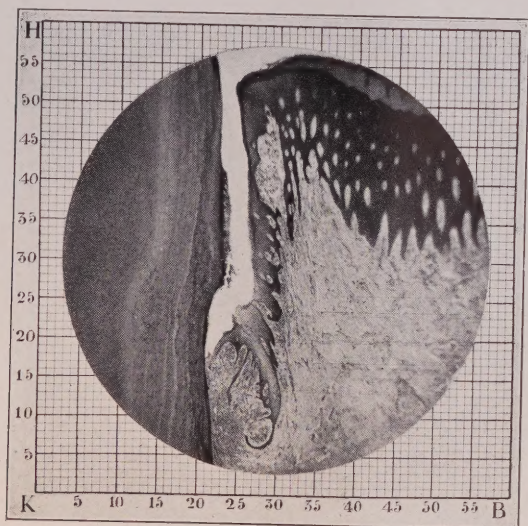


FIG. 66—X40. PERIODONTAL POCKET (SHEEP)

Showing the epithelium covering the soft tissues to its base. The epithelial lining is much thinner than that of the gingival mucosa, comparable to the differences seen in tonsillar crypts.



FIG. 67—X80. PERIODONTAL POCKET

This higher magnification of the base of the pocket seen in Fig. 66 shows the finger-like extensions of epithelium penetrating, in various directions, the sub-epithelial granulation tissue.

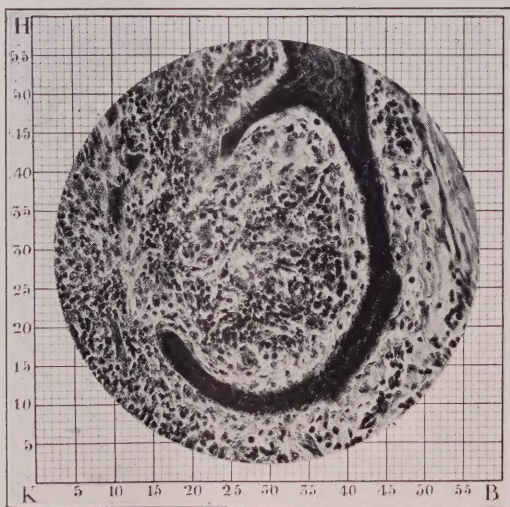


FIG. 68—X200. PERIODONTAL POCKET

This is a still higher magnification of the deepest epithelial strand shown in Fig. 67. Note the granulation tissue into which it is extending.

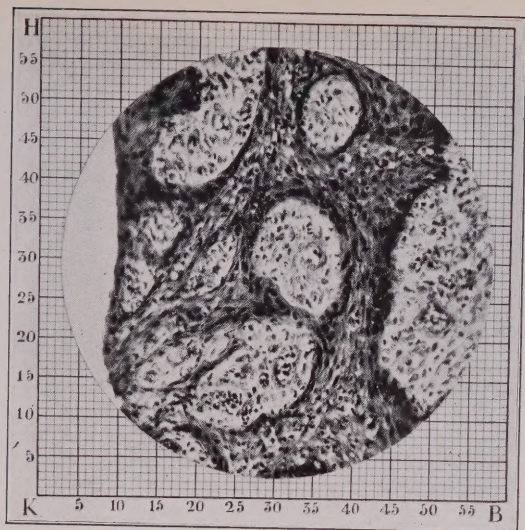


FIG. 69—X200. PERIODONTAL POCKET (HUMAN)

Small zone of soft tissue wall of pocket showing thin layer of epithelium covering the connective tissues, and extending from it, various penetrating epithelial strands.

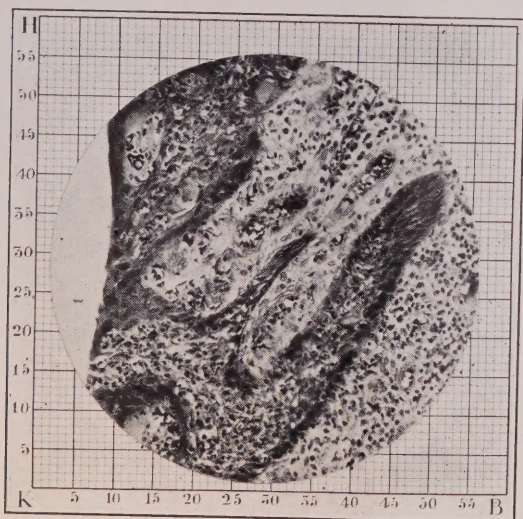


FIG. 70—X200. PERIODONTAL POCKET (HUMAN)

Small zone of soft tissue wall showing finger-like extensions of epithelium, growing from the surface into the underlying tissues.

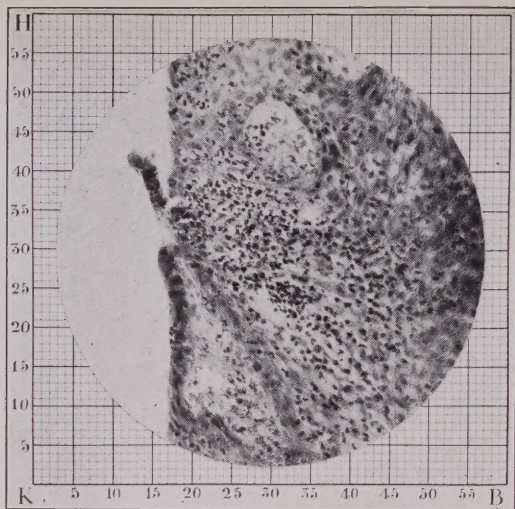


FIG. 71—X200. PERIODONTAL POCKET (HUMAN)

Small portion of soft tissue wall of pocket showing minute break in the epithelial lining with zone of acute inflammatory reaction in the adjacent underlying connective tissue.

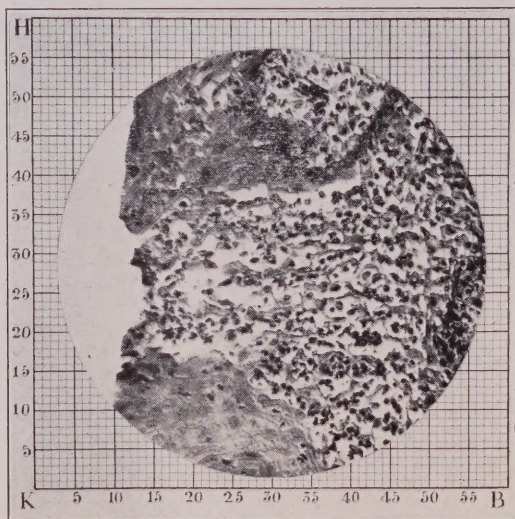


FIG. 72—X265. PERIODONTAL POCKET (HUMAN)

Small zone of soft tissue wall of pocket showing a break in the epithelial lining and cellular infiltration in the exposed connective tissue.

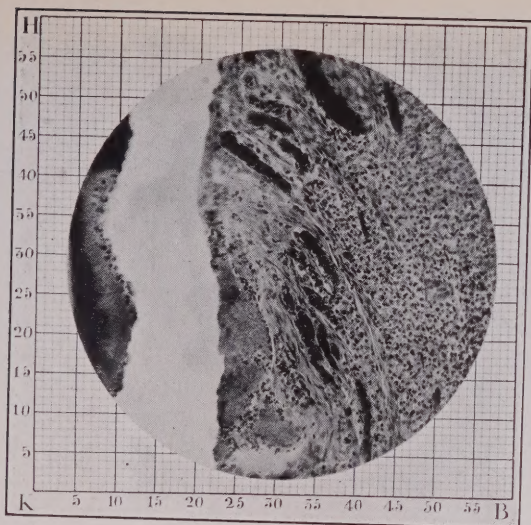


FIG. 73—X200. PERIODONTAL POCKET (HUMAN)
 In this photomicrograph is shown the rich capillary bed which has developed opposite the irritant—a nodule of calculus.

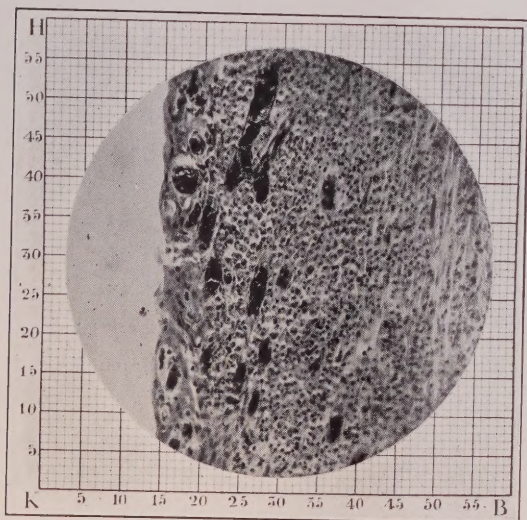


FIG. 74—X200. PERIODONTAL POCKET (HUMAN)
 Another demonstration of the capillary bed of the granulation tissue in the soft tissue wall of the pocket. Note also the thinness of the epithelial layer.

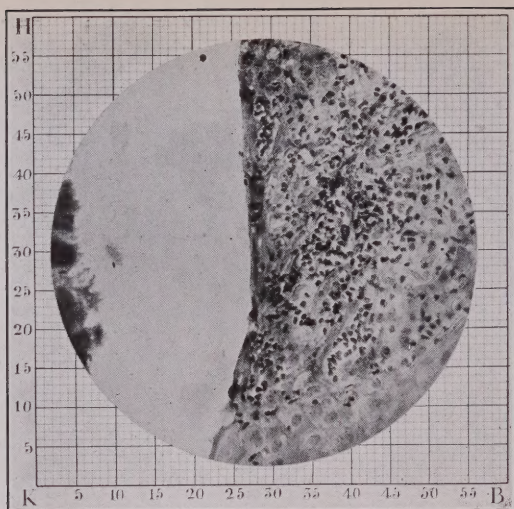


FIG. 75—X265. PERIODONTAL POCKET (HUMAN)

This photomicrograph presents a small part of the soft tissue wall of the pocket showing capillary reaction and hemorrhage in the tissues opposite a nodule of calculus. Note also the extremely thin covering of epithelium.

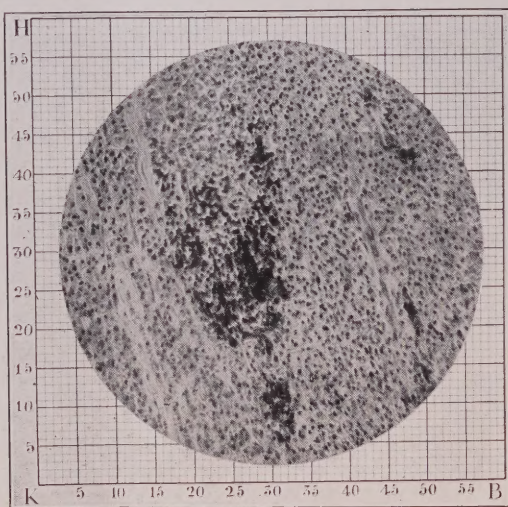


FIG. 76—X265. PERIODONTAL POCKET (HUMAN)

This illustration shows in the granulation tissue of the pocket wall zones of hemorrhage. By diapedesis the red blood-cells have become extravasated, passing through the vessel-walls without rupture.

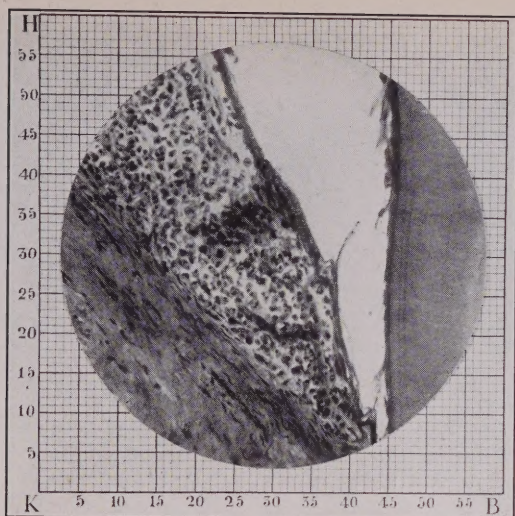


FIG. 77—X265. PERIODONTAL POCKET (HUMAN)

This photomicrograph shows, on the right of the pocket, the tooth with its cementum cuticle; on the left, a layer of granulation tissue resting upon sound fibrous connective tissue, and covered with epithelium. In periodontal curettement the granulation tissue and epithelium are removed.

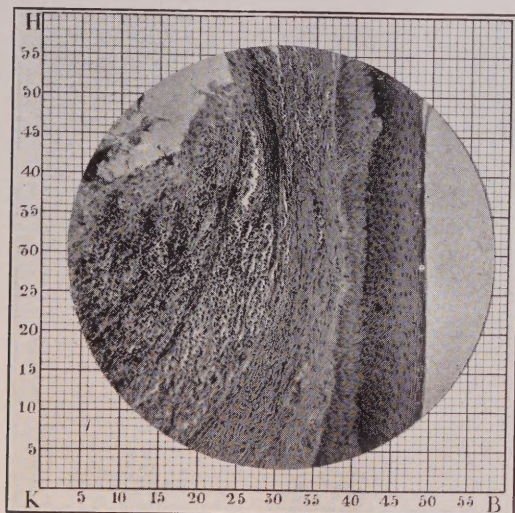


FIG. 78—X100. PERIODONTAL POCKET (HUMAN)

In this illustration a condition is demonstrated in which the formation of the granulation tissue, on the left, has resulted in almost complete destruction of the fibrous connective tissue.

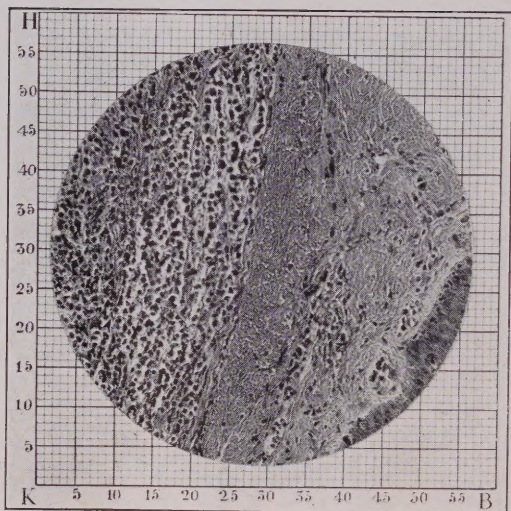


FIG. 79—X200. PERIODONTAL POCKET (HUMAN)

This photomicrograph is a higher magnification of the condition shown in the preceding illustration. The junction of the layer of granulation tissue and the remaining fibrous tissue is well defined.

PART III

CASE MANAGEMENT OF COMPLEX AND SIMPLEX PERIODONTITIS

First Phase.—*Examination*

(a) Complete radiographic survey of the teeth and alveolar structures.

(b) Pulpal vitality tests.

(c) Study casts mounted in articulator—Hanau Articulator and Technique⁴¹ preferred by the writer. This makes possible an exhaustive examination of the patient's occlusions and articulations.

(d) Clinical examination of the teeth and periodontal tissues and a determination of pathological conditions and etiological factors present. The pocket depths are measured by special gold or silver probes marked in millimeters. Fig. 80.

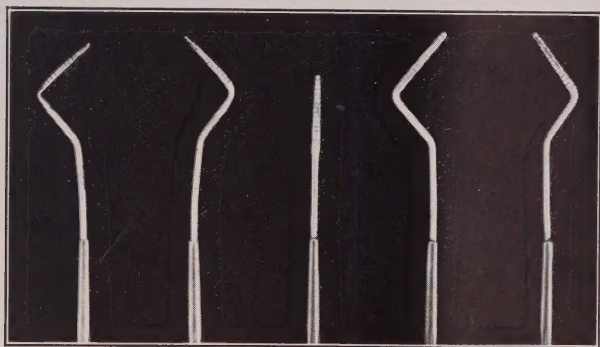


FIG. 80. BOX PERIODONTAL PROBES

These instruments are used for the detection of pockets, and the measurement of the pocket-depth in millimeters. (E. C. Platt, Maker.)

All the clinical findings should be carefully recorded on a chart.

Based on the evidence presented in the complete examination, with the pathology of periodontal diseases and associated syndromes in mind, a diagnosis is arrived at, a prognosis made and treatment-outline selected.

Taking first Complex Periodontitis, the following order of the various steps of treatment has been chosen by the writer as a typical average of hundreds of cases managed in his practice. This sequence has unquestionably played an important part in the uniformity of results achieved, and is presented with full confidence that the dentist who bases his management of treatment of this disease upon it, with modifications, begins his case with a decided advantage.

Second Phase—*Treatment* (Complex Periodontitis)

(a) *Superficial Scaling of Teeth Indicated for Extraction*

The presence of gross deposits on the tooth and their proximity to a rich capillary circulation in the gingivae favours the mechanical passage of bacteria into the blood-stream or adjacent tissues during extraction. The removal of these deposits prior to tooth extraction is clearly a logical procedure. A general scaling-and-polishing of the teeth, however, is contra-indicated as a first step in treatment because of its very marked disturbance of existing gingival and periodontal signs; examples of these are traumatic crescents, asymmetric marginal gingival recessions, Stillman's clefts, festoons, and absence of stippling. For further discussion of these premonitory or incipient lesions the reader is referred to recent papers by Stillman⁴² and the writer.⁴³ Fig. 81.

These signs are very characteristic of the relationship existing between certain etiological factors, and their transformation into the normal tissue background which follows as a response to therapeutic procedures, constitutes a most important aid in the proper valuation of these causal factors. It has been the experience of the writer that the tissue-responses following the relief of traumatic occlusion alone have been of much greater moment, in the appraisal of the whole, than those following the removal of gingival irritants, which in Complex Periodontitis are of secondary consequence. That is to say, while not underestimating the fact and importance of the rapid changes that take place in the gingival tissues, following careful instrumentation, it is of much greater significance to be able to recognize in the tissues the effects of the pernicious factor of traumatic occlusion and the changes which take place in the tissues when, of the etiological factors, it alone has been removed. The import of its true relation to infection,

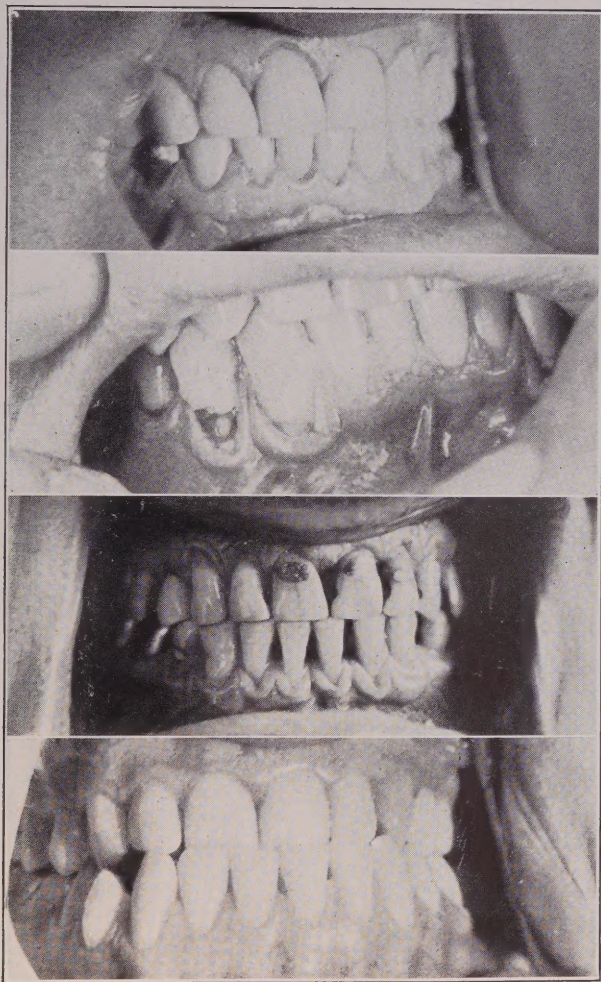


FIG. 81—FOUR SIGNS OF INCIPIENT PERIODONTAL DISEASE, VIZ., TRAUMATIC CRESCENTS, STILLMAN'S CLEFTS, FESTOONS AND ABSENCE OF STIPPLING.

(Photographs by permission of Dr. Paul R. Stillman.)

deposits and other findings, quite apart from mobility, is soon revealed to the careful observer. As a point of interest, the reader is referred to a recent article by Withycombe.⁴⁴

Therefore from the foregoing any procedure which changes the gingival picture in any detail, prior to the correction of traumatic occlusion and reduction of pericemental overstress, is strictly contraindicated, as it would thereby mask the true underlying conditions. In this class belong the procedures of scaling, polishing, the application of medicaments, pastes or salves, and the use of vaccines, astringent or antiseptic mouth washes. In a brief paper,⁴⁵ eight years ago, the writer called attention to this obscuring influence of scaling on the gingival signs of traumatic occlusion. Further, it is emphasized that nothing be done to change the patient's habits of oral hygiene. It is best to avoid, at this time, any discussion of the subject with the patient; the institution of a correct mouth toilet would undoubtedly serve to disturb the finer details of the gingival picture.

(b) *Extraction of Hopelessly Diseased Teeth*

Teeth with such involvement of the periodontal tissues that prognosis is negative; certain teeth, the presence of which obviously makes impossible the establishment of balanced articulation; and teeth the associated tissues of which from topographic reasons persist as sites of bacterial incubation are examples.

That extraction of condemned teeth should precede the adjustment of occlusion is obvious.

(c) *Occlusal Equilibration or the Establishment of Physiological Occlusion*

It will be recalled that pocket formation in Complex Periodontitis is relatively a late symptom and preceded, as a rule, by increased mobility of the tooth in its alveolus. Treatment of the pocket is preceded also by the establishment of physiological occlusion as far as this is possible. Relief from pericemental overstress produced by traumatic occlusion is the first fundamental requisite in the treatment of Complex Periodontitis and for the following reasons:

(1) Physiological occlusion insures that the periodontal structures receive their normal functional stimuli and, when natural, is associated, as a rule, with normal mobility of the tooth in its alveolus. The periodontal tissues then tend to have a good circula-

tion, adequate nourishment and prompt removal of waste products. They are allowed to remain in a healthy and quiescent state wherein they are able to resist harmful influences of various kinds which bring about pathological changes in them. Acquired physiological occlusion and relief from pericemental overstress is followed, as a rule, by a marked increase in firmness of the tooth in its socket. With this tightening process the tissues are much less readily invaded by bacteria. This increase in tissue-resistance is shown in a marked degree in the process of pyogenic infection where the amount of pus exuding from the pocket is usually decreased to a noticeable degree in three or four days. It follows, therefore, and is borne out in practice, that treatment of a pocket on a tooth of normal mobility, or one rapidly approaching it, is much less subject to the complication of secondary infection than when carried out on a tooth of marked mobility.

(2) Mobility interferes with the healing process through the agency of which reattachment of the soft tissues with the tooth takes place. It is obvious that when reattachment is the aim of the operator it is of first importance that the tissues operated upon will have the most favourable condition possible for repair.

(3) Experience has shown that when readjustment of the occlusal relations has been completed prior to scaling and curettement, with a period of rest intervening, that the tissues tend to bleed less freely during these operations. As the success of these procedures depends largely upon the sense of touch and a knowledge of the anatomy of the parts, this is a matter of minor importance. However, it points to the important fact that hyperemia of the tissues is greatly reduced.

(4) Further, it is common knowledge among periodontists that when scaling and curettement are carried out after occlusal readjustment that the attendant pain or discomfort is, as a rule, greatly diminished. This is true for both dental and periodontal walls of the pocket. Equally important is the clinical fact that the length of the period of after-soreness is greatly decreased. It has been the observation of the writer that in general this period is approximately one-third of the corresponding period of after-soreness when instrumentation has been proceeded with before the occlusal equilibration.

It is possible that prosthetic restorations are indicated at this

stage of treatment-management, as an important measure in the establishment of physiological occlusion.

In regard to occlusal equilibration, it may be of interest to quote an early authority in England. In 1821 Eleazar Parmly published "An Essay on the Disorders and Treatment of the Teeth," in which he states in the part dealing with periodontal disease that "the only assistance to be expected from the dentist is the removal of all impurities from their surfaces, and the *lessening as much as possible the pressure of the upper and under teeth against each other.*"

(d) *Superficial Scaling*

When the gingival and periodontal tissues have displayed their maximum response to the relief from pericemental overstress, or have shown in the transformation of the various prodromal signs that great regenerative changes are under way, a general scaling-and-polishing of the teeth is indicated. It is not the practice of the writer to scale the periodontal pockets to the base at this time, but to confine attention to the removal of deposits immediately under the gum margin. The objective at this stage is the production of a sanative influence upon the entire oral cavity and the preparation of the field for the surgery of the pockets.

(e) *Surgery of the Pocket*

Conservative Method (semi-radical or radical methods if indicated).

- (1) Deep scaling.
- (2) Cemental curettement.
- (3) Periodontal curettement.

These procedures will be discussed at greater length in subsequent paragraphs.

(f) *Instruction in the Care of the Mouth*

The institution of a suitable technique to provide sanitation and gingival stimulation with demonstration in the mouth of the patient. The Stillman⁴⁶ modification of Charter's method is advocated. It will be noted that this sequence differs radically from accepted case-managements in that this important step follows, rather than precedes, occlusal readjustment, scaling and pocket surgery. Apart from the bearing on the gingival premonitory signs pointed out previously this departure from the usual method of practice is made for the following important reason. Holman⁴⁷

has stated that "Kuczynski⁴⁸ showed that pressure on the tonsil could force bacteria into the circulation and Schmidt⁴⁹ found that such a procedure altered the cellular composition of the blood. These results, and the knowledge of the constant periodic compression of the tonsils in swallowing, would strongly suggest that this mechanism of infection must be common and that the role of the tonsils in focal infection is therefore more important than that of many other infected foci."

The periodontal pocket is comparable in many ways to the infected tonsillar crypt. When the histo-pathology of the periodontal pocket is considered, with its thin epithelium, rich capillary bed, and rough calcific deposits, it becomes obvious that there is a possible danger of unloading its bacteria into the blood-stream through vigorous massage either from the tooth-brush or the finger. It appears, therefore, that in Complex Periodontitis, with its narrow and deep pockets, it is sound practice to postpone vigorous brushing and massaging until the deposits are removed and the capillary beds are eliminated.

From the foregoing it is apparent that in many instances where no teeth are indicated for extraction, steps (a) and (b) are omitted. Management of treatment then resolves itself into the following four major steps:

- (a) Occlusal Equilibration.
- (b) Superficial Scaling.
- (c) Surgery of the Pocket.
- (d) Instruction in proper care of the mouth.

Second Phase—*Treatment* (Simplex Periodontitis)

(a) Superficial and deep scaling where semi-radical treatment (thorough periodontal curettement), or radical measures (gingival excision, etc.) are to be employed. Where the conservative method (*i.e.*, combination of deep scaling, cemental curettement, and periodontal curettement) is indicated, superficial scaling only is carried out as the first step.

- (b) Extraction of teeth indicated for removal.
- (c) Surgery of the pocket:

- (1) Semi-radical; periodontal curettement only.
- (2) Radical—gingival excision; so-called flap-operation.
- (3) Conservative—combination of deep scaling, cemental and periodontal curettement where reattachment is the aim of the operator.

(d) Instruction in the care of the mouth—sanitation and gingival stimulation.

For general home care: A solution made from the following powder, $\frac{1}{4}$ teaspoonful to $\frac{1}{2}$ glass of warm water, has been found to be a valuable adjunct when used on the brush with the Stillman method of brushing. When a dentifrice is indicated as well, its use should precede that of the solution.

The formula of the powder is as follows:

Phenolphthalein.....	2 grains
Saccharine.....	7 grains
Menthol.....	15 grains
Calcium oxide.....	100 grains
Sodium chloride.....	1 pound

When sensitive dentine has been encountered excellent results have been obtained in the writer's practice through the use of the remineralization powder of Andresen of Copenhagen. Lind prescribed this powder as a prophylactic in hundreds of cases and found that its use yielded splendid results in superficial decalcification of the enamel and sensitive denuded dentine, and that it proved to be a rational and effective measure against caries. According to Lind,⁵⁰ "the principle on which this remineralization method is based is to raise by artificial means the concentration of the mineral salts which normally are dissolved in the saliva, and in this way raise the normal hardening process of the enamel, which process takes place by diffusion into it of the mineral salts."

The formula is as follows:

Acid tartaric.....	g. 90,
Sol. gelatin alb. 10%.....	g. 10,
M. exsic. et ad.	
Phosphat. calcic praecip.	
Carbon. calcic. praecip.	
Hydratocarbon. magnesic.....	aa g. 32
M. et ad	
Chloridi natric. sic.....	g. 32,
Bicarbon. natric.....	g. 113,
Saccharine.....	g. 0,50
Ol. menth. pip.....	g. 2,
M. et exsic. exact. d. in vitro s. Pulv. dentifricii.	

We advise our patients to use this powder on a moist tooth-

brush and the brushing to be carried out according to the Stillman method twice daily.

Third Phase—*After-Care* (both Complex and Simplex Periodontitis)

- (a) Further instruction in the use of the tooth-brush.
- (b) Such scaling and polishing as is necessary until control of oral hygiene is established by the patient.
- (c) Examination and such procedures as scaling and occlusal equilibration at intervals determined by the condition found.

THE TREATMENT OF THE PERIODONTAL POCKET; AUTHOR'S METHOD

In considering the question of the periodontal pocket from the standpoint of treatment we shall be interested not only in removing the causes of the disease but in planning a sequence and method of operation which will promote the most rapid and complete healing. It forms a great part of the skill of the periodontist to be able to leave the tissues upon which he has operated in the most favourable condition for repair. Those conditions embrace the mechanical adjustment of the periodontal tissues whose union to the root is sought, and the exclusion of past or present mechanical irritations which might embarrass the tissues in their efforts to throw off any infection remaining at the base of the pocket. It may be safely assumed that nutrition will be adequate because of the abundant blood supply which is characteristic of these tissues. Post-operative measures for the exclusion of secondary infection must also receive careful consideration. This is a matter which requires special thought because of the constant presence in the mouth of innumerable pathogenic bacteria.

The procedures to be undertaken in the treatment of the periodontal pocket comprise the following:

- (a) Scaling.
- (b) Cemental Curettement
- (c) Periodontal Curettement.
- (d) Establishment of the clot.
- (e) Sealing of the pocket.

(a) Scaling.—The scaling as used in this treatise is a term which describes an operation for the removal of calcific deposits and other foreign matter from the root-surface within the periodontal pocket. Because of the firm attachment and hardness of most of these

deposits, their removal can only be accomplished through the use of steel cutting instruments. In order that the periodontal tissues which make up one wall of the pocket shall not be unduly traumatized during this operation, it is essential to select scalers whose design will permit them to slip into the orifice of the pocket without causing distension of the soft tissues. It is possible to use scalers of both the hoe and curette type for this operation. The author has found the following to be satisfactory for this purpose:

- (1) McCall's, No. 4, 5, 7, 8, 9, 13, 14. (S. S. White).
- (2) Waktassi, PBD. No. 1, 2, 3, 4, 5, 6, 7, 8; PDD. No. 2, 4, 6, 8. (W. A. Kelsey).
- (3) Julian Smith's, No. 5, 6. (Ivory).

Fig. 82-88.

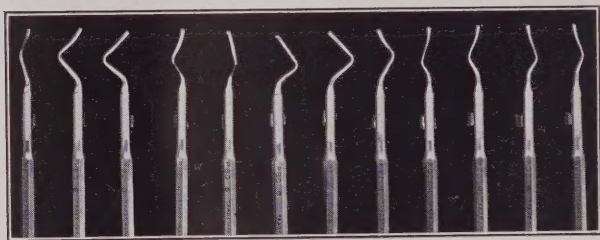


FIG. 82—WAKTASSI SCALERS

The principle of the "Waktassi" True Axis is simply that the three points, viz., fulcrum, power section and work point or cutting edge are made to fall in a straight line with each other. (W. A. Kelsey, Maker.)

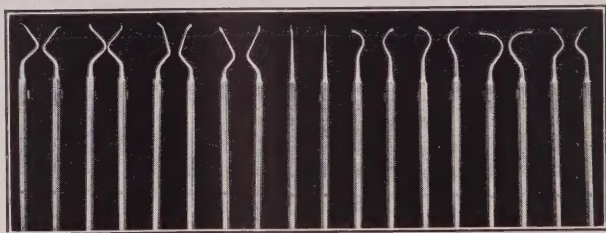


FIG. 83—MCCALL SCALERS—CURETTE TYPE—(S. S. W.)

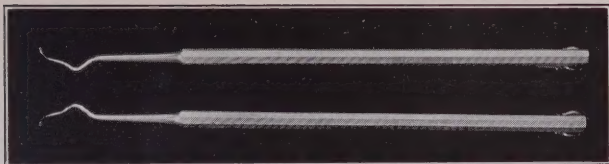


FIG. 84—JULIAN SMITH SCALERS—NOS. 5 AND 6 (IVORY)

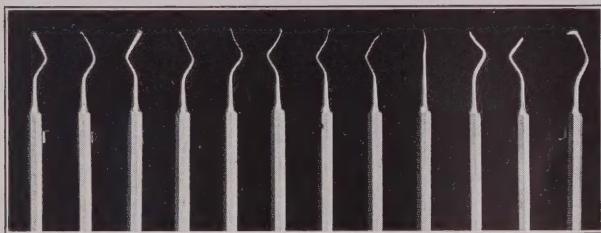


FIG. 85—MCCALL SCALERS—HOE TYPE—(S. S. W.)

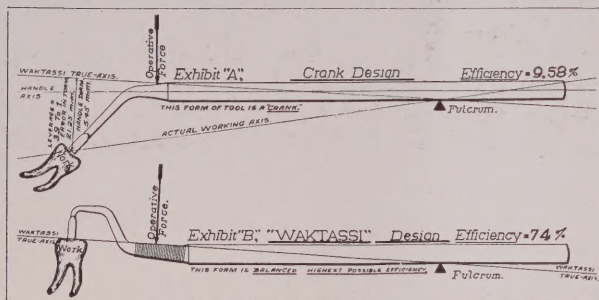


FIG. 86—In this diagram, an instrument of crank design, Exhibit A, clearly shows the difference in design from that of the Waktassi True Axis form, Exhibit B. Exhibit A has an efficiency rating of 9.68% of work done, for power expended to do the work. Exhibit B has an efficiency rating of 74%.



FIG. 87—WAKTASSI PLANE HOLDING DEVICE (SHARPENER)

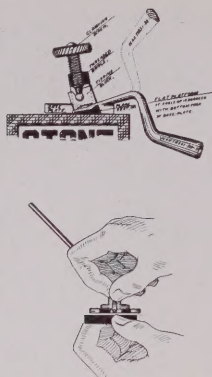


FIG. 88—In the upper diagram there is shown the manner in which the instrument is held in the Waktassi Plane Holding Device and its method of contacting with the sharpening stone which, for the purpose of illustration, is presumed to be resting upon the cabinet shelf. When held in the hands, as shown in the lower diagram, by pushing the sharpening stone easily and gently across the blade, the blade is sharpened with one or two wipes.

The essential points in scaling are sharpness of instrument, selection of instrument for accessibility, and finger-rest. In selecting an instrument it is important that it shall reach the site of operation, that it shall not distend the soft tissues when inserted into the pocket, and that the operator's hand shall be in a comfortable position, *i.e.*, not cramped while operating. The control of the instrument is obtained by the finger-rest. Since the object of this operation is to remove all foreign matter from the root-surface, with a minimum of trauma, it is essential that the instrument be held firmly to its work and that there shall be no slipping.

(b) Cemental Curettement may be defined as the surgical treatment of the root-surface for the complete removal of the cementum cuticle, together with such cemental tissue as may be required for the promotion of reattachment. A study of these tissues indicates that it is sometimes necessary to completely remove the cementum at some given spot in order that the requirements of healing may be met. Histological evidence and clinical experience both indicate that this procedure is justifiable. A study of the photomicrographs presented herewith will point to the rationale of the procedure. The ultimate object in the conservative treatment of the periodontal pocket is to secure the reattachment of the connective tissues to the root-surface. Since these are both of mesodermic

origin, and since the cuticle is of ectodermic origin, it seems essential that this latter tissue be removed if a stable reattachment is to be expected. Furthermore, if the cementum surface exhibits irregularities such as excavations, spicules, etc., the irritation which would be produced by the rough surface so created would tend to interfere with normal healing. The author has introduced a special cemental curette which is intended to produce a smoothly planed surface on the cementum or outer dentine layer. The blade presents a single cutting edge, the bevel of which is formed by the angle at which a flat kerf meets a concave face. It is a finishing instrument rather than a scaler, and is not intended for the removal of calculus or general scaling procedures.

Special features of the Cemental Curette:

(1) Its planing action is self-limited; the cutting edge planes best when the fulcrum in the head is raised slightly above the surface; when touching, a very limited action is obtained. When elevated beyond a certain point the planing action stops.

(2) The instrument is thus designed to work best when the cutting surface is the only part of the instrument in contact with the tooth, a feature which allows the finest perception in the sense of touch.

(3) The cutting edge is so placed that it makes an angle which allows a smooth-working planing or shaving effect.

(4) The right-angle corners are eliminated so that the danger of making small grooves in the cementum is removed.

(5) The median line of the working edge is so placed as to be on the line of the long axis of the handle, a feature which makes for greater control and increased delicacy of operation.

(6) The angle of the cutting edge to the shank also lends itself to universal use in curetting the cementum in pockets.

(7) The working head is designed so that the stroke of the instrument is from the base of the pocket to the surface, thus bringing the shavings of cementum to the opening of the pocket where they can readily be removed.

Because of the novel features of design incorporated in this instrument it is recommended that the beginner practise the use of this instrument on extracted teeth before attempting to use it in the mouth. Figs. 89-90.

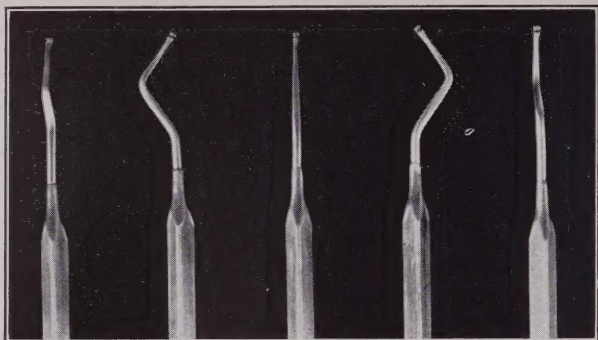


FIG. 89—BOX CEMENTAL CURETTES (E. C. Platt, Co-designer and Maker).

(c) Periodontal Curettement may be defined as the surgical removal of the epithelial lining of the pocket and the underlying granulation tissue. This operation may best be performed by means of a special instrument designed to cut on the sides and also to cut as it is withdrawn from the pocket, thereby withdrawing the operated tissue as the instrument is removed from the pocket. Curettes of the Younger type have been found unsatisfactory for performing this operation. An instrument introduced by the author which has given most gratifying results is illustrated in this treatise.

The basis of reattachment obviously lies in the production of a blood-clot in a surgically clean field of operation. To secure this desired state of cleanliness it is recommended that no foreign

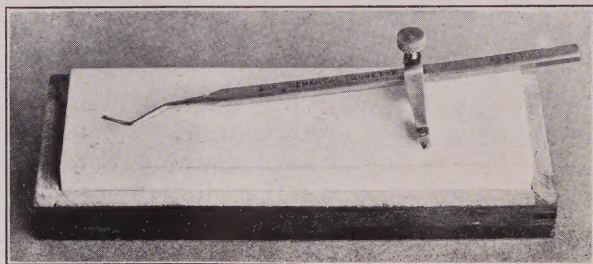


FIG. 90—BOX CEMENTAL CURETTE IN PLATT SHARPENER ON ARKANSAS OIL STONE

substance be introduced during the operation, such as antiseptic or other medicaments. Furthermore, the practice of injecting or otherwise introducing pastes or salves into the pocket after curettement is finished is to be unhesitatingly condemned. Such practice must inevitably defeat the object of the operation, *viz.*, the securing of a reattachment.

The periodontal curette is designed for cutting soft tissues only, and presents a concave blade with five cutting edges. These are so arranged that the tissues may be curetted in three different directions from any given position in the pocket.

Special features of the Periodontal Curette:

(1) The peculiar design of the head of the instrument makes possible the curettement of not only the face of the soft tissue wall of the pocket, but the more inaccessible periodontal-cemental junctions as well, both laterally and at the pocket-base.

(2) The head of the curette is specially tempered and sharpened so that the edges cut the tissues with the minimum of pressure, eliminating undue crushing.

(3) The shape of the head insures the easy removal of the severed tissue.

(4) The cutting edges are so arranged that when the head is properly inserted in the pocket the soft tissues tend to overlap them, thus facilitating their excision.

A study of the photomicrographs will indicate that the operation of periodontal curettement is not complete until the instrument

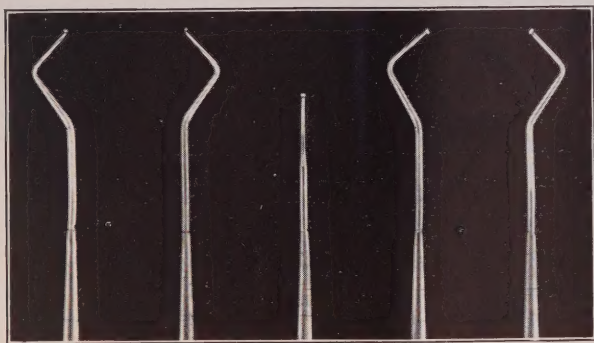


FIG. 91—BOX PERIODONTAL CURETTES (E. C. Platt, Co-designer and Maker)

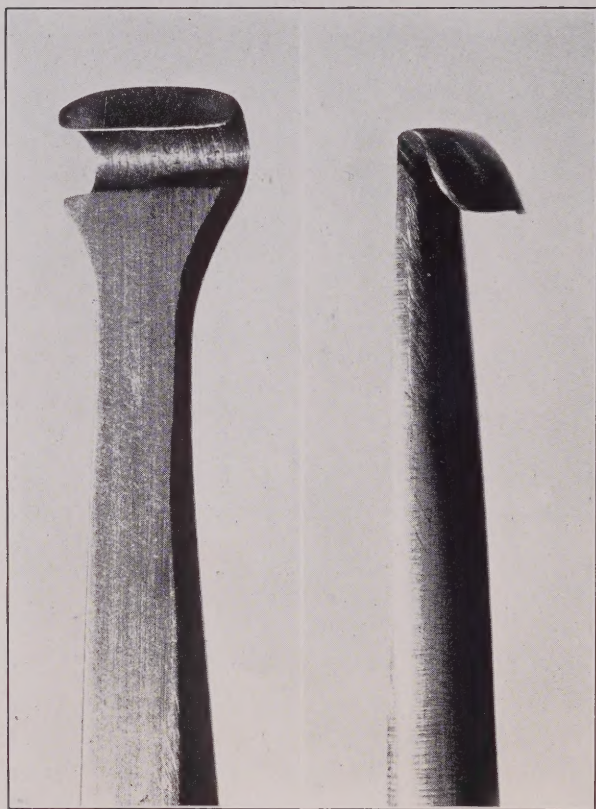


FIG. 92—In this illustration there is shown on the left a photographic enlargement of the head of a cemental curette; on the right is to be seen a photographic enlargement of the head of a periodontal curette.

has removed all granulation tissue thereby penetrating to the normal fibrous tissue of the part. Clinically the attainment of this objective may be determined by the aid of the ear and the sense of touch. When the instrument reaches the fibrous tissue it produces a characteristic ringing sound and a feeling of resistance which is unmistakable. Figs. 91-92.

(d) Establishment of the Clot.—With the completion of the periodontal curettement, formation of a satisfactory blood-clot as a rule takes place. If this does not take place, or if the clot which has formed is disturbed for any reason, it may be necessary to gently freshen the curetted soft tissue surface again to induce bleeding and the formation of another clot. While the blood is clotting it is advantageous to compress the soft tissues against the tooth with the finger for one minute with sustained gentle pressure.

(e) Sealing of the Pocket.—Based on histologic and clinical evidence it may be stated that secondary infection from within the periodontium will not occur provided the foregoing procedures have been correctly carried out. It is, therefore, to be regarded as good practice to seal the orifice of the pocket at the time for the protection of the blood-clot and to maintain the coaptation of the soft tissues with the root. This is accomplished by the use of a varnish made by dissolving copal gum in alcohol (25 grains in 100 minims). Another tenacious varnish, and one which has been found to be soothing to unusually tender tissues, is made as follows:

Copal Solution (alcoholic) 25%.....	50 minims
Tincture Tolu.....	5 “
Oil of Thyme.....	1 “
Ether.....	10 “

First isolate the tooth by means of cotton rolls, dry the tissues and tooth with cotton followed by warm air and apply the varnish copiously and allow it to harden. If the patient is careful about the use of the tooth-brush and harsh foods, this seal will remain in place from two to three days. At this time it may be repeated if it is found desirable. Figs. 93-96.

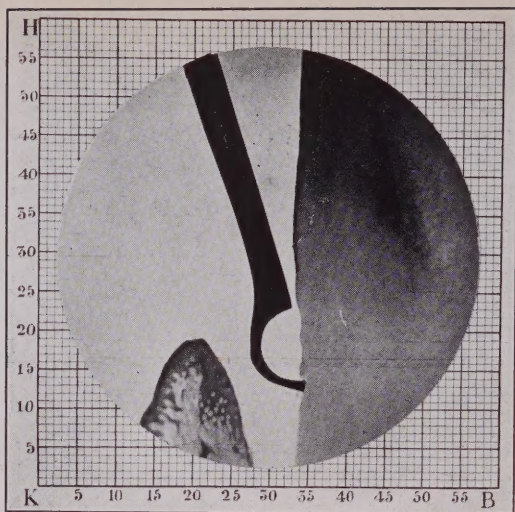


FIG. 93—In this photomicrograph a longitudinal section of a cemental curette is shown in approximately its proper relation to the tooth surface for curettement. The section of the steel instrument was prepared by E. C. Platt, co-designer, and placed in the position in the section shown in the illustration by the author.

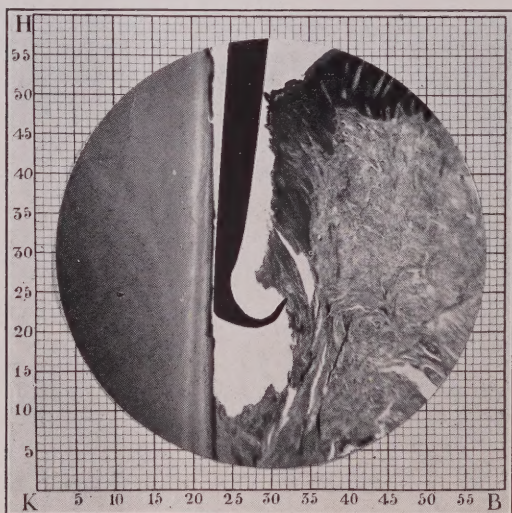


FIG. 94—This photomicrograph shows a section of a periodontal curette in a periodontal pocket in position for curettement of the soft tissues. The section of the periodontal curette (steel) was prepared by E. C. Platt and placed in the position shown by the author.

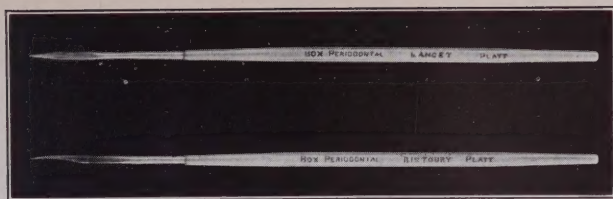


FIG. 95—PERIODONTAL LANCET AND PERIODONTAL BISTOURY
The lancet is two-edged while the bistoury has but one cutting edge. (E. C. Platt, Maker



FIG. 96—Examples of author's hand-positions in scaling and curettement.

REATTACHMENT AND ALVEOLAR REGENERATION

The writer's concept of reattachment is dependent upon the following important factors:

(1) The claims of prominent periodontists that reattachment of the soft tissues to the root is a clinical fact, *e.g.*, the affirmations of Younger, Smith (T. Sydney), Stillman, McCall, Merritt and others. Younger⁵¹ was the first to claim that actual reattachment takes place. The following is his statement: "The treatment of pyorrhea alveolaris, by the method recommended by myself to you several years ago, is meeting with unabated success in my hands. Teeth hanging by apical attachment only have been rendered firm and the tissues of the diminished sockets made so to contract and unite with the roots that an instrument could not be introduced between them without force and causing pain and bleeding. I am satisfied that reattachment takes place in these cases, otherwise the teeth could not become so firm and the gums and tissues of the socket cling so to the tissues of the root. It is, therefore, an easy matter for direct union to be established between these healthy living tissues when the partition of calculus is thoroughly removed from the root and a granulating surface produced in the environing soft tissues of the gingivus."

Smith⁵² (T. Sydney) has stated: "Periodontal diseases are not cured until the pyorrheal pockets have been entirely obliterated. It has been found that the separated tissues will form a reattachment to the roots of vital teeth when proper surgical assistance is given. This reunion removes all traces of the pyorrheal pocket."

Merritt⁵³ also states: "It is a matter of indifference which type (of instruments) is employed so long as the conditions essential to success are met. When this is done reattachment takes place, pockets are obliterated, new bone is deposited about the roots, the teeth become firm and health is re-established in the tissues, though complete restoration to previous conditions may not occur; in advanced cases there will probably be gum recession."

Stillman⁵⁴ says: "All will soon be obliged to admit that a cure does not result unless there is a complete obliteration of the pocket and a reattachment of the gingiva to the root of the tooth, when the gingival circulation becomes normal and takes on a healthy colour."

(2) The opinions of noted dental investigators on the question of reattachment, *e.g.*, Noyes, Bunting, Gottlieb.

Noyes⁵⁵ has stated: "That the tissues may be reattached to the surface of the root is both theoretically possible and clinically demonstrable, but for this to occur biological laws must be observed, and the conditions are very difficult to control, especially with the old methods involving the excessive use of strong antiseptics."

Bunting⁵⁶ recently states: "We know that when conditions are favourable and the operative procedures have been completely performed, a physical reattachment of the soft tissues to the root to obliterate the pyorrheal pocket does take place in a large percentage of cases."

Gottlieb⁵⁷ has expressed his opinion as follows: "A reattachment such as is described by Box and McCall is undoubtedly theoretically possible and these authors have also verified this possibility by histologic examination."

(3) Clinical Observations of the Author:

(a) One of the first examples, apart from pocket-treatment, of the ability of the soft tissues to become attached to the cementum was noted in a case of extraction of a Lower First Molar. A fairly long strip of gingival tissue, detached towards the mesio-buccal of the socket margin, was found doubled backwards, forming a loop, with its free end in contact with the mesio-proximal cemental surface of the Second Molar. On close examination this gingival tag was found to be firmly adherent to the cementum, and stoutly resisted separation when tugged with the pliers.

(b) A second convincing example, the writer has noted a great many times, *viz.*, the ability of the gingival tissues to become reattached to the cementum, when, through gingival procedures incident to extraction, the soft tissues, including the gingivae, have been laid back to expose the alveolar bone. Close adaptation to the original position against the cementum with gentle digital pressure, for about thirty seconds, appeared to be the only precaution taken to insure reattachment. These cases were later carefully examined and probed.

(c) Examples of reattachment following conservative surgical treatment of the pocket have been noted in abundance. This is not to say, however, that union is always assured when the necessary procedures appear to have been taken. Results, in general, as is to be expected, occur in ratio to the detail with which the various procedures are carried out. The writer is convinced that these are

not mere appositions; critical tests and observations place them in the class of physical reattachments through organic union.

(4) Histological evidence in the author's possession:

Experiments were undertaken to demonstrate the various stages of regeneration in the soft tissues following the surgery of the pocket with the writer's technique; also to determine the character and mechanism of reattachment itself. Based upon these findings to be shown later in this treatise, and those less recent, reported in the work "Studies in Periodontal Pathology," it is reaffirmed without hesitation that reattachment, when the proper procedures are undertaken, is a proven biological fact. Fig. 97.



FIG. 97—In this illustration three examples of extracted teeth with excised tissues, including curetted pockets, are shown. From specimens such as these the microscopic sections were made in the study of the problems of healing following treatment and reattachment.

Based on these findings, which in reality are snapshots of the healing process taken at periods of twenty-four hours, three days and nine days, and also several years later, we conceive the process of organization following the double curettement to be as follows:

Following the removal of the epithelial lining and the underlying granulation tissue with the periodontal curettes, the soft tissues are given a final gentle freshening of the surface which induces further bleeding. As a rule the use of these curettes is

followed by the formation on the inner wall of the soft tissues of a uniformly dense clot. It usually extends slightly beyond the mouth of the pocket. This clot-extension or "flag", as we have termed it, is a favourable sign clinically. It has been observed that this projection has, as a rule, disappeared by the end of the third day, with the indication that satisfactory organization of the fibrin in the pocket has begun. This clot passes down into the pocket, diminishing in thickness towards its base, and cementing the soft tissues to the tooth.

When examined microscopically at the end of twenty-four hours the oral projection or "flag" presents a delicate network of fine fibrils in which are entangled numerous leucocytes evenly distributed. The red blood-cells at this stage and in this region were few. Some eosinophiles are present, and also an occasional fibroblast is to be seen near the border of the clot.

The fibrin fibrils of the clot are closely adherent to the curetted connective tissues. The reparatory process is probably initiated by the amoeboid extension of the nearby connective tissue cells which find guidance in the fine threads of fibrin. Through their proliferation and that of the endothelial cells of the blood-vessels some new tissue is soon formed. Figs. 98-99.

Microscopic examination at the end of the third day reveals the presence in the fibrin of a few fibroblasts near the boundary of the fibrin and the old connective tissue. Besides mononuclear wandering cells, polymorphonuclear leucocytes and red corpuscles, some lymphocytes are to be noted. Fragments of curetted cementum are also present here and there throughout the fibrin. Figs. 100-101.

The relation of the leucocytes to fibroblastic proliferation is of special interest at this point. Carrel⁵⁸ has pointed out "that lymphocytes and large mononuclear leucocytes can live in serum and manufacture from its constituents growth-promoting substances." He states: "Fibroblasts are endowed with an unlimited capacity for growth. They proliferate as long as they are supplied with the proper nutritive medium." He states further that "leucocytes can set free in vivo the growth-promoting substances which they manufacture;" also that "small and large lymphocytes may bring to fixed cells the substances required for their proliferation and supply adult tissue with the substratum for cicatrization and regeneration."

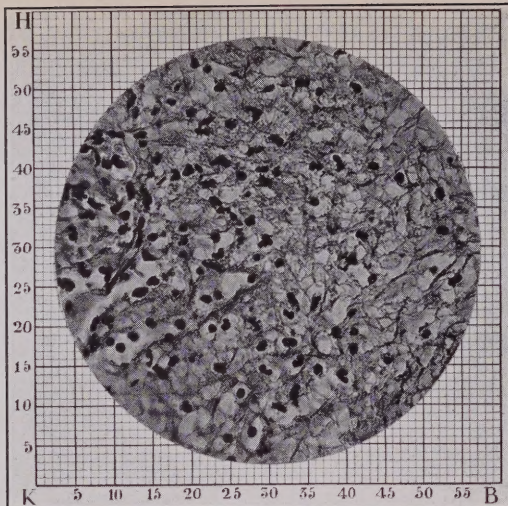


FIG. 98—X400. ORGANIZATION FOLLOWING CURETTEMENT (ONE DAY)
This photomicrograph of a section of clot-projection or "flag" at the end of twenty-four hours shows a delicate network of fibrin fibrils in which are entangled numerous leucocytes.

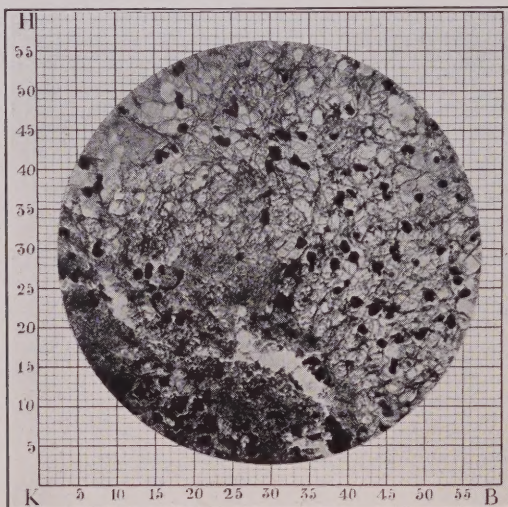


FIG. 99—X400. ORGANIZATION FOLLOWING CURETTEMENT (ONE DAY)
Here also is shown a photomicrograph of a section of the clot at the orifice of the pocket twenty-four hours after curettage. This clot adheres to both the soft tissues and the tooth, and extends, as a rule, slightly beyond the pocket opening. This projection is known clinically as a "flag." Note in the illustration the delicate fibrils of fibrin and the leucocytes.

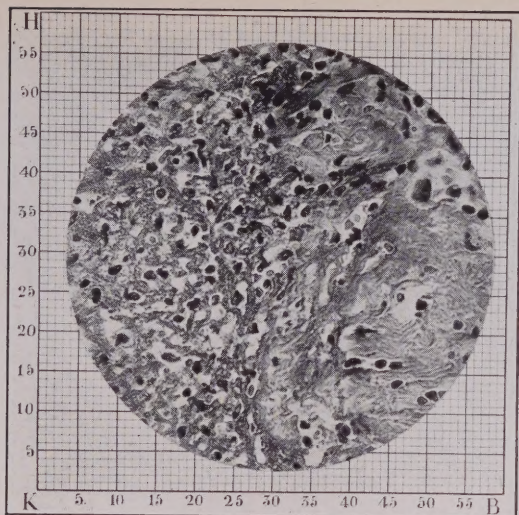


FIG. 100—X400. ORGANIZATION FOLLOWING CURETTEMENT (THREE DAYS)

This photomicrograph shows the junction of the fibrin mass and the old connective tissue. The fibrin fibrils at the left of the figure are closely adherent to the curetted connective tissue, at the right. Leucocytes and occasional fibroblasts are to be seen, also fragments of curetted cementum.

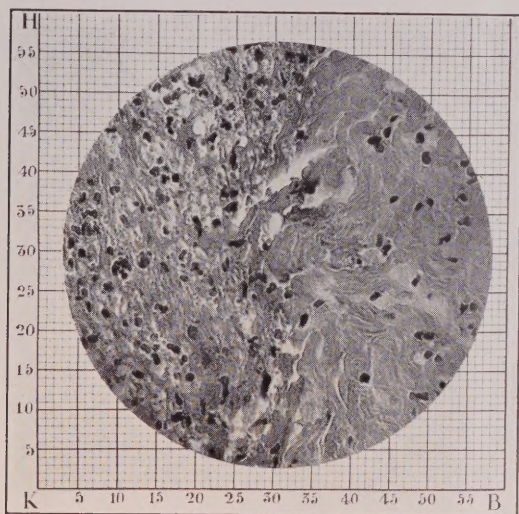


FIG. 101—X400. ORGANIZATION FOLLOWING CURETTEMENT (THREE DAYS)

This illustration is another example of the junction of the fibrin mass and old connective tissue at the end of three days following thorough curettage. The specimen was not taken from the same case as shown in Fig. 100, but presents the same conditions. The fibrin clot (left) is closely adherent to the curetted soft tissues (right). Through the stretching forward into the fibrin of the sprouts of endothelial cells and the accompanying fibroblasts the fibrin is gradually removed.

Through the stretching forward into the fibrin of the sprouts of endothelial cells and the accompanying fibroblasts with their long branched processes of protoplasm, the fibrin is gradually removed and replaced by a more permanent bond of new tissue.

The specimens examined microscopically at the end of nine days show a well-marked band of new tissue consisting of abundant blood-vessels and young fibroblasts spread apart by a more or less homogeneous intercellular substance. Some fine fibrils are beginning to make their appearance between the cells. Here and there throughout the young tissue, as noted in the fibrin band of three days, small fragments of curetted cementum are to be seen. There are also shown large multi-nucleated cells. These are termed foreign-body giant cells and, as is well known, are particularly prone to form about certain types of foreign bodies in the tissues. On the planed cemental surface, which evidently affords the young cells an excellent support on which to creep, the young fibroblasts with large oval pale-staining nuclei and long protoplasmic extensions are to be seen. They appear to be surrounded by a somewhat homogeneous intercellular substance which has formed in the closest adaptation to the surface of the cementum, and which later differentiates into definite bundles of fibres. Figs. 102-103.

The epithelium has extended inwards from the gingival margin and has shown a remarkable tendency to cover the exposed surface of the granulating tissues. Due to its inherent vital characters, it tends to grow in a sheet or continuous membrane and to cover all the exposed surface of the connective tissue. The extent of this surface in the healing process following curettement is probably in direct ratio to the existence of several factors, among which gingival disturbance from food-excursions and tooth-mobility are prominent. The use of the tooth-brush must also be included.

That such a relation of the young connective and epithelial tissues with the cementum as manifested in nine days should have much value as an attachment from the standpoint of tensile strength is hardly to be expected. Its significance, however, is great in that it forms, through the union of the young fibrous tissue and the cementum especially, the basis for an attachment of much greater worth.

Later this young connective tissue matures into a fairly firm fibrous tissue, with a few flattened nuclei lying in closely pressed bundles of fibrils. The fibroblasts break at their extremities into

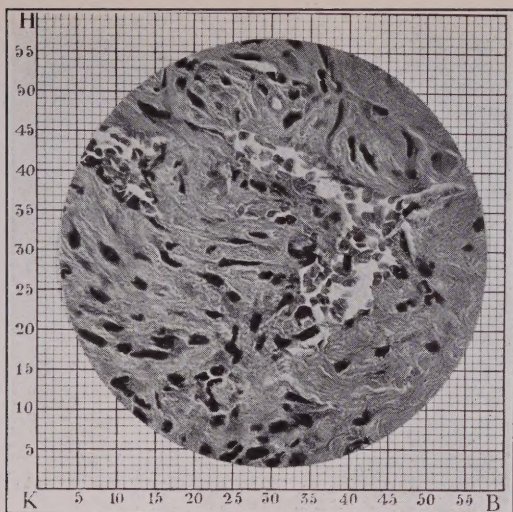


FIG. 102—X400. ORGANIZATION FOLLOWING CURETTEMENT (NINE DAYS)

This photomicrograph shows the junction of old and new tissues nine days after curettage. At the left of the illustration is to be noted a well-marked band of new tissue consisting of abundant blood-vessels and young fibroblasts. Note also that the junction of the tissues has become less distinct.

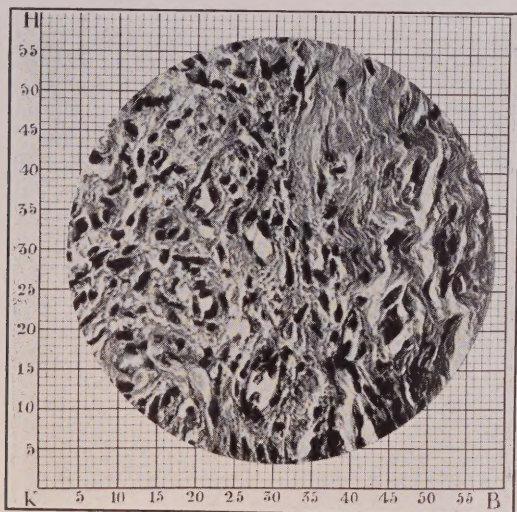


FIG. 103—X400. ORGANIZATION FOLLOWING CURETTEMENT (NINE DAYS)

Here also is shown the junction of the old and new tissues, and the formation of a band of new tissue consisting of blood-vessels and young fresh fibroblasts. The new tissue is at the left of the illustration and the old tissue at the right; note the comparative indistinctness of the junction of the tissues. Fragments of curetted cementum are frequently to be seen in the new tissue.

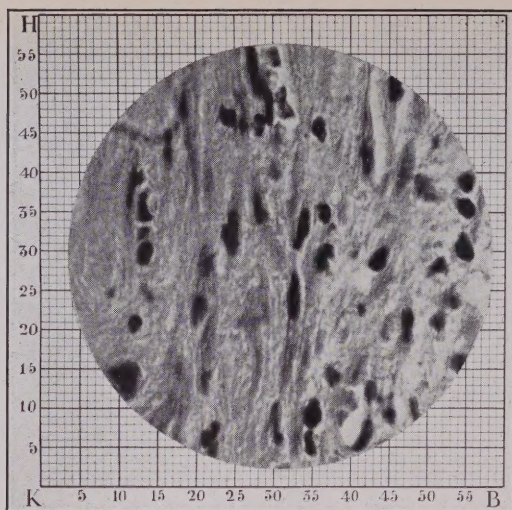


FIG. 104—X800. ORGANIZATION FOLLOWING CURETTMENT (NINE DAYS)
 This photomicrograph shows a high magnification of the new tissue which has been formed in nine days following the curettment of the soft tissues. Note the young fibroblasts with their long protoplasmic processes.

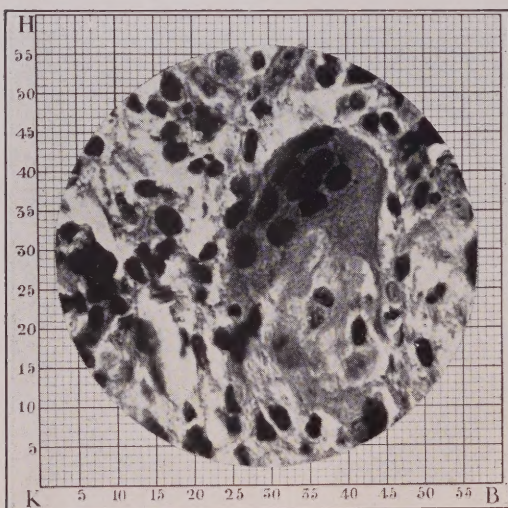


FIG. 105—X800. ORGANIZATION FOLLOWING CURETTMENT (NINE DAYS)
 There is shown in this photomicrograph a large foreign-body giant cell noted in the young granulation tissue. It is of extraordinary size and contains many nuclei. These giant cells seem to be concerned in the attempt to dissolve foreign substances.

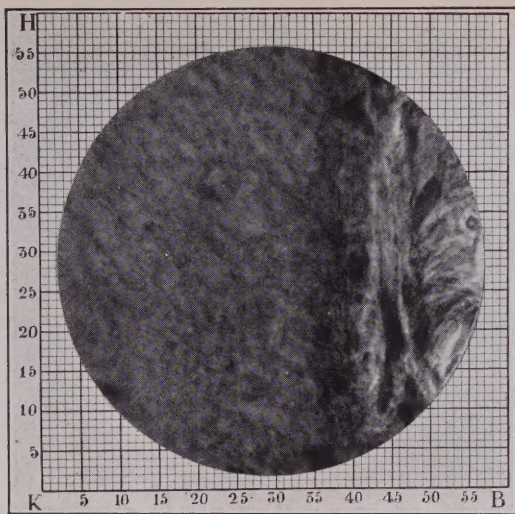


FIG. 106—X800. ORGANIZATION WITH YOUNG REATTACHMENT (NINE DAYS)

This photomicrograph shows several young fibroblasts with their long protoplasmic extensions and the surrounding intercellular substance on the curetted cemental surface nine days after curettement of the soft tissues.

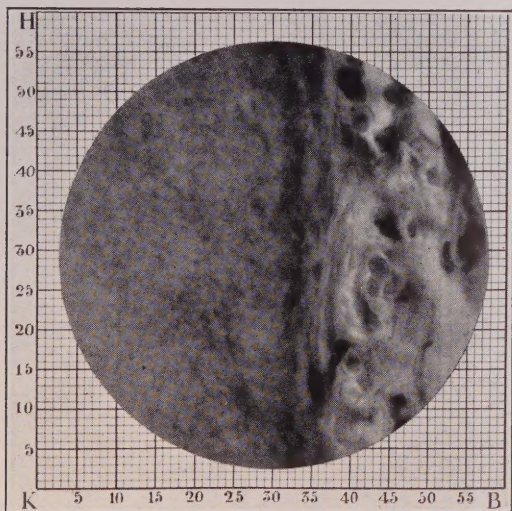


FIG. 107—X800. ORGANIZATION WITH YOUNG REATTACHMENT (NINE DAYS)

Here also is shown a photomicrograph of the cemental surface nine days after curettement, on which are to be seen young fibroblasts and intercellular substance which is in the closest adaptation to the surface of the tooth.

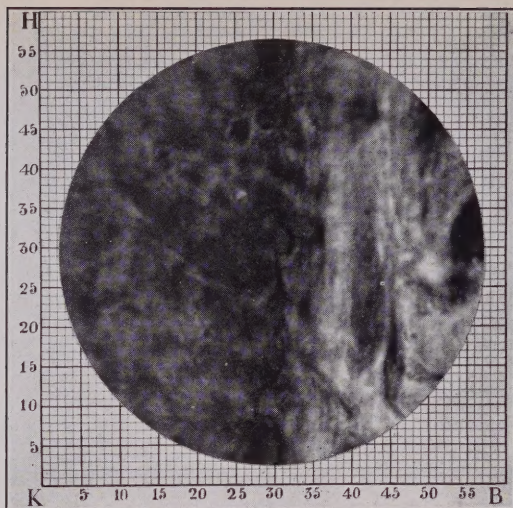


FIG. 108—X1700. YOUNG REATTACHMENT (NINE DAYS)

This photomicrograph shows a very high magnification of two young fibroblasts on the cemental surface nine days after curettage. Note their long protoplasmic extensions.

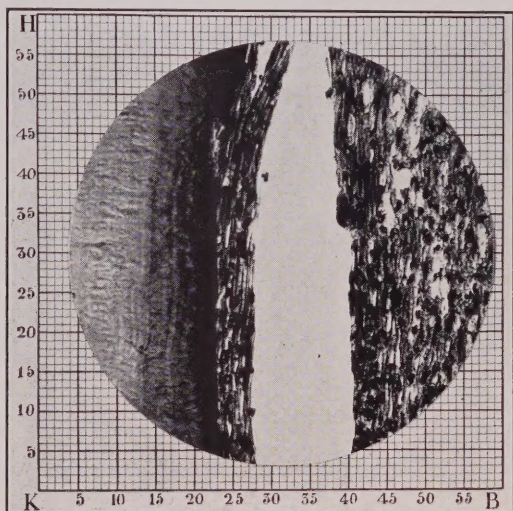


FIG. 109—X400. OLD REATTACHMENT (EPITHELIAL)

Here is shown the tenacious adherence of the epithelial attachment to the tooth surface. The cleavage in the epithelial attachment was produced in the preparation of the section.

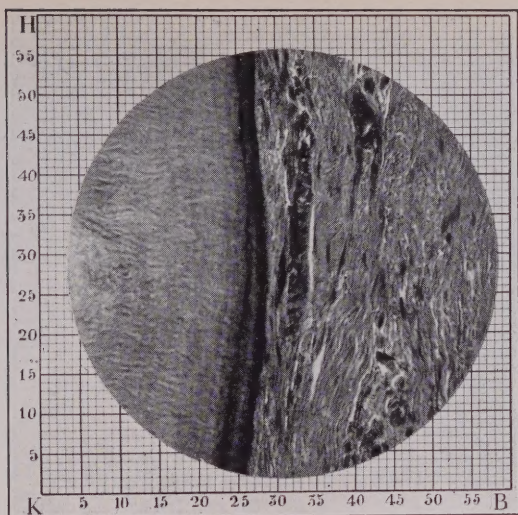


FIG. 110—X400. OLD REATTACHMENT (CONNECTIVE TISSUE)

This photomicrograph shows reattachment of the connective tissue with the tooth. Note that the connective tissue fibre-bundles lie parallel with the cemental surface. On the surface of the cementum a new layer of cementum has been formed. This is clearly shown in the illustration.

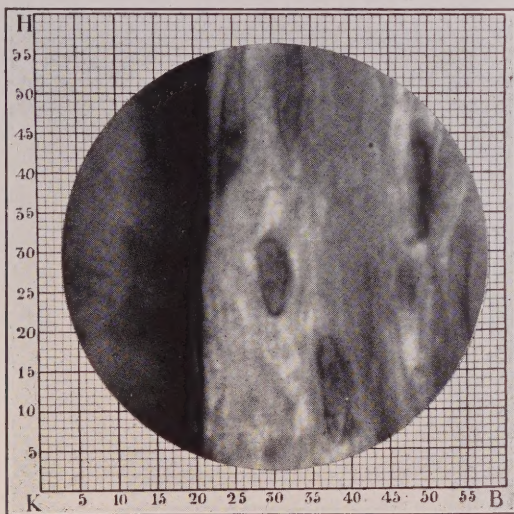


FIG. 111—X2500. OLD REATTACHMENT (CONNECTIVE TISSUE)

In this very high magnification the cells and intercellular substance of the mature fibrous connective tissue adjacent to the tooth surface are shown. Note the flattened nuclei lying in closely pressed bundles of fibrils. In this extreme magnification it is worthy of note that the hard and soft tissues are in the closest coaptation.

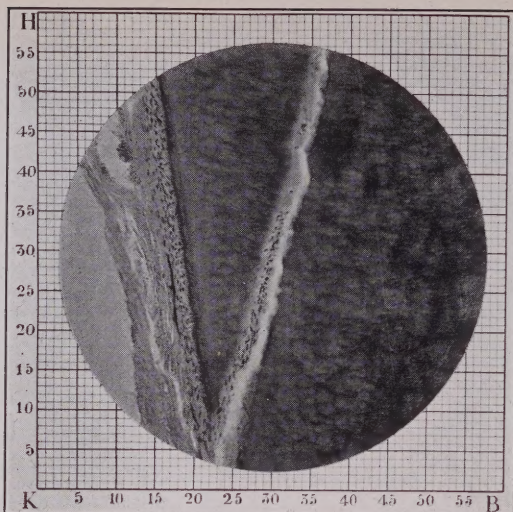


FIG. 112—X100. HEALING FRACTURE OF THE TOOTH

This photomicrograph shows a fissure formed through the fracture of the dentine into which the pericemental cement-forming connective tissue cells have proliferated. Note that these cells have extended to the extremity of the fissure.

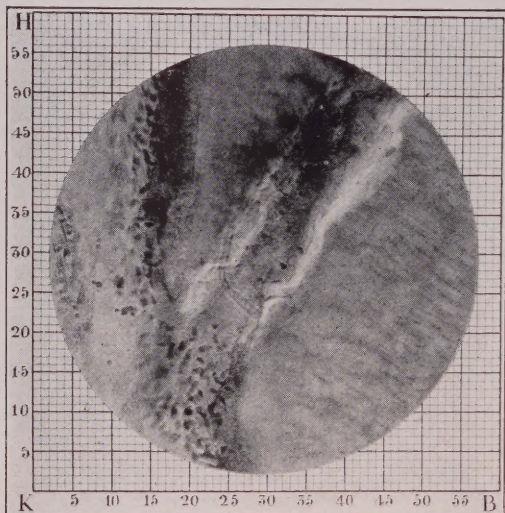


FIG. 113—X200. HEALING FRACTURE OF THE TOOTH

This illustration of the opening of the fissure formed through the fracture shows the deposition of a formless ground-substance or cement-matrix. Note the enclosed cement-corpuscles.

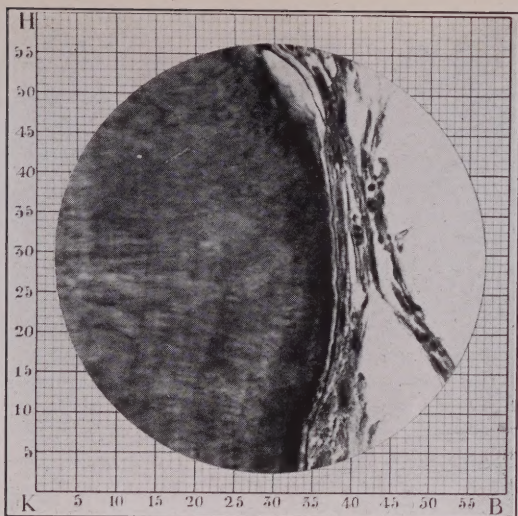


FIG. 114—X600. OLD REATTACHMENT

This photomicrograph shows a zone of curetted cemental surface and its adherent epithelial attachment with the formation of a cementum cuticle.

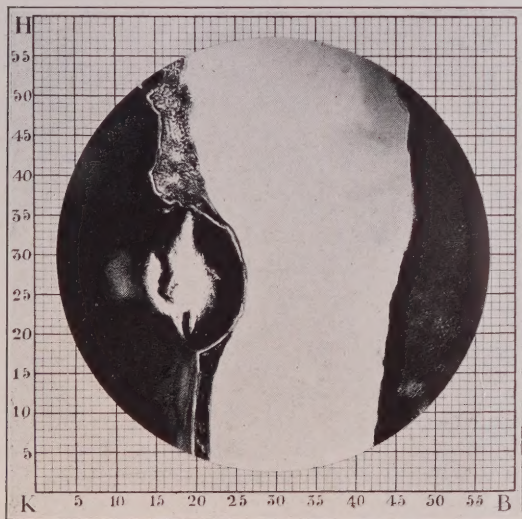


FIG. 115—X200. CEMENTUM CUTICLE FORMATION FOLLOWING CURETTEMENT

Here is shown on the curetted tooth surface a cementum cuticle which has been formed by the epithelial reattachment. With separation of the soft tissues from the tooth the cuticle has remained on the cementum.

fine processes, and also along their sides fine parallel fibrillae are formed through modification of the protoplasm. As this continues the cells become smaller, the nuclei flattened and the cicatricial tissue decreases in volume.

In certain instances new cementum is formed. Noyes⁵⁹ has pointed out: "In order to accomplish this, the tissues must lie in physiologic contact with the surface of the root and the connective tissue cells must be actively functional." When and under what conditions new cementum is first laid down the writer is not in a position to state at the present time. That it does occur can hardly be denied from an examination of the specimens. Figs. 109-111.

A splendid example of the reparative powers of the pericemental connective tissue and its ability to form new cement-substance under suitable conditions is to be seen in a case where, through trauma, a fracture of the dentine has occurred. Following proliferation and extension of pericemental connective-tissue cells, which are cement-forming, into the fissure formed by the break of continuity in the outer dentine, there is deposited on the fissure-walls a formless ground-substance. This cement-matrix presents here and there enclosed cement-corpuscles, and later with deposition of calcium throughout, it becomes hard like bone or cementum. Figs. 112-113

The epithelial attachment in time forms a new epithelial cuticle. This is well shown in Fig. 114. On separation this cuticle has remained on the tooth. Fig. 115.

BEARING OF THE HISTOLOGIC FINDINGS UPON PERIODONTAL PRACTICE

(a) With the fairly rapid and deep ingrowth of epithelium along the tooth surface there appears to be a constant tendency towards the formation of a gingival crevice. While the epithelium, through the inherent vital character of the cells, tends to grow and spread out over a surface, the writer feels that the extent of this surface over the curetted tissues bears some relation to the amount of gingival disturbance through food excursions and the mobility of the tooth in its alveolus. We agree with Skillen and Mueller⁶⁰ that we must distinguish between a physiologic ideal and a physiologic normal as shown in the gingival crevice. At the same time care must be taken to protect the gingival tissues from undue movement,

and the use of the copal varnish and relief from traumatic occlusion are means to this end.

(b) While the epithelium and underlying granulation tissue were fairly difficult to remove, special difficulties were not encountered. A simple surgical freshening of the surface, as advocated by some writers, is obviously inadequate where a connective tissue reattachment is the objective. Special attention must be given, in curetting, to the base of the pocket and the gingival margin. A well-curetted gingival margin tends to delay the epithelial ingrowth.

(c) The cases operated upon by the writer were given the greatest care, that is to say, the scaling, cemental curettement and periodontal curettement were carried out thoroughly and in the proper order. Special attention was given to the procedure of periodontal curettement; each pocket was curetted gently from ten to fifteen minutes with the periodontal curettes, and then sealed with the copal varnish. Based on the care taken and the results achieved, it would appear that many of the reported attachments are epithelial in origin—genuine reattachments, nevertheless, but without the worth of the fibrous connective tissue type.

(d) It is clear that in the zone of reattachment there can be no deposition of new cementum in that portion covered by epithelium. In the arrangement of the reattached tissues on the curetted cemental surface, it would appear from the findings that the proportional relation of the epithelial reattachment to that of the connective tissues is determined fairly early, that is to say, within nine days or less. It seems reasonable that increase in the relative amount of connective tissue reattachment may be achieved through gentle recurettement of the outer portion of the pocket. There is little objection to this, on clinical grounds, from the standpoint of secondary infection.

(e) The histologic specimens show that the cemental curettement did not present special difficulties. Calcific deposits and cementum cuticle were thoroughly removed and the cemental surfaces were not unduly indented or grooved. Complete loss of the cementum must be expected in many cases.

(f) There is no evidence of secondary infection in the soft tissues. The two common causes of reinfection are first, failure to thoroughly curette the granulation tissue at the base of the pocket, and second, inadequate protection of the pocket opening

from oral bacteria. Special attention to the pocket-base and the careful sealing of the pocket by copal varnish will, as a rule, prevent reinfection.

ALVEOLAR REGENERATION

Additional evidence has been accumulating since the author's earlier statement on this subject, which makes it seem reasonable to reaffirm the contention that alveolar regeneration is possible in cases of periodontal disease. Cases exhibiting radiographic evidence of this regeneration have multiplied not only in the practice of the author, but in the hands of many others in the profession. Arguments against this hypothesis are usually based on statements of variation in the X-ray angulation, exposure or development. With the perfection of X-ray technique, however, these variables can readily be eliminated. With uniform exposures and development, radiographs showing evidence of bone regeneration may be accepted as authoritative. Figs. 116-120.

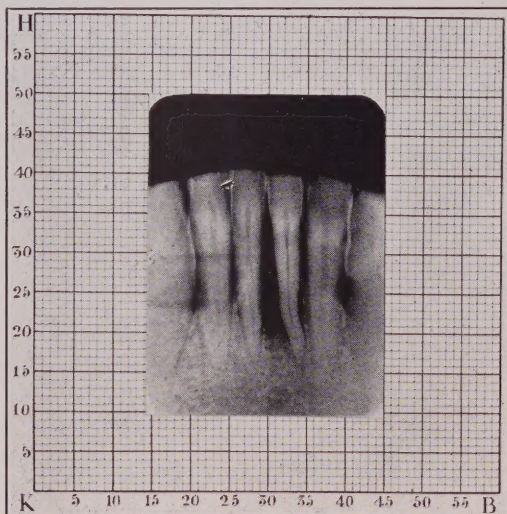


FIG. 116—REGENERATION OF THE ALVEOLAR BONE

This radiograph was taken March 1, 1921, before treatment was begun by the author. Note the marked alveolar rarefaction between the Lower Central Incisors (median line).

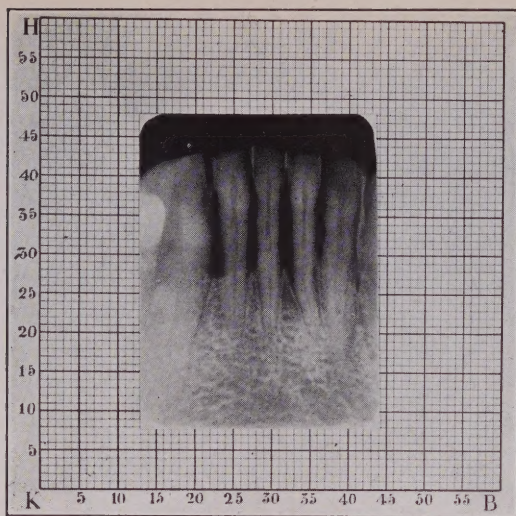


FIG. 117—REGENERATION OF THE ALVEOLAR BONE

This radiograph of the same case was taken one year later, March 1, 1922, and shows a great restoration of the alveolar bone between the Central Incisors. (Radiographs by Dr. J. W. Coram.)

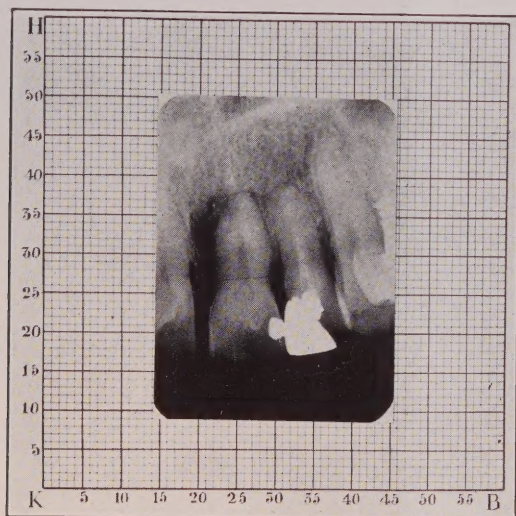


FIG. 118—REGENERATION OF THE ALVEOLAR BONE

The radiograph shown in this illustration was taken April, 1926, and presents a marked alveolar rarefaction on the mesial of the Upper Right Central Incisor. This rarefaction extends slightly beyond the root-apex, and with the use of a probe a pocket was revealed which extended to the tip of the root. Treatment was carried out by the author according to the case-management described in this treatise. The Right Lateral was extracted, restoration made, occlusion balanced, and surgery of the pocket carried out, viz., scaling, cemental curettement and periodontal curettement.

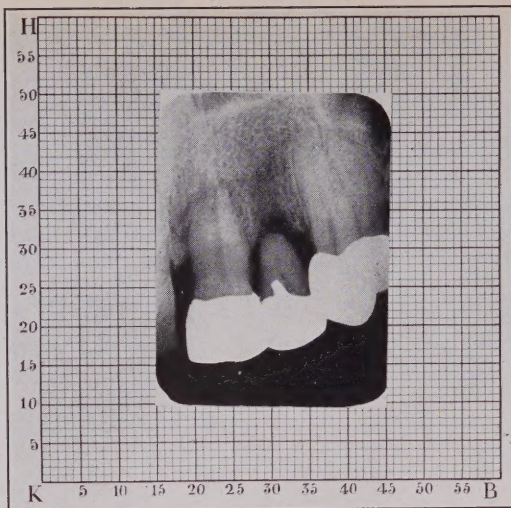


FIG. 119—REGENERATION OF THE ALVEOLAR BONE

This radiograph of the same case, as shown in Fig. 118, was taken in October, 1926. Note the great regeneration which has taken place in the alveolar bone on the mesial of the Right Central.

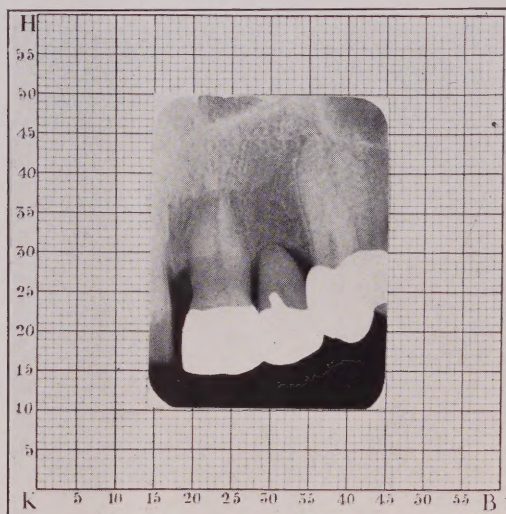


FIG. 120—REGENERATION OF THE ALVEOLAR BONE

This radiograph was taken in May, 1927, and shows the region presented in Figs. 118 and 119. It reveals the extensive restoration of alveolar bone which has occurred since April, 1926, between the Upper Central Incisors. On careful examination of this region in the mouth it was found that the pocket was obliterated, and that the soft tissues were apparently reattached to the tooth. (Radiographs by Dr. Robert M. Box.)

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125

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HAROLD KEITH BOX.

Impressions in Partial Denture Service

Including a Technique for (1) Mucosa-Supported and (2) Tooth- or Root-Supported and (3) Combination of Root- and Mucosa-Supported Partial Dentures



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48. Molding and casting the special tray in Plaster or in an Investment Mold rather than in Calcar.
49. A Rectangular Matrix with a Universal Adjustment within its Limits for making Plaster Molds.
50. Casting Special Trays of Tin by Gravity in a Plaster or Investment Compound Mold made from a disappearing wax Pattern.
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Introductory

1. PARTIAL DENTURE SERVICE AND THE IMPRESSIONS

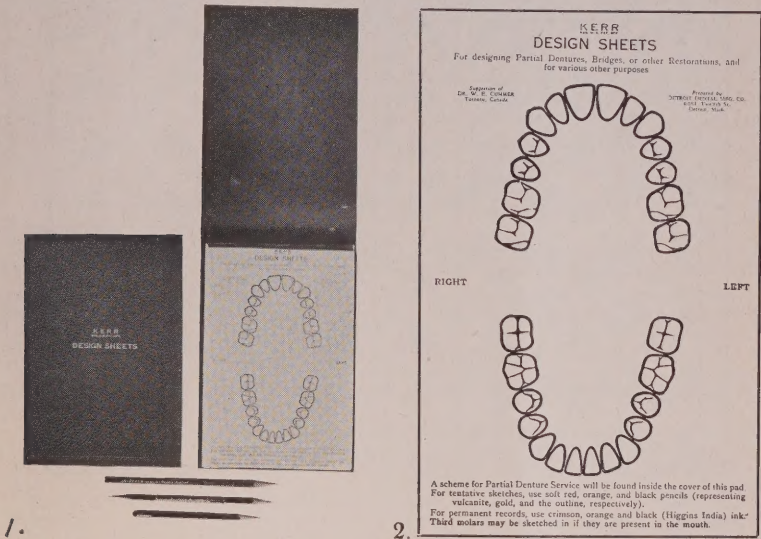
One of the conceptions of the practice of partial denture service naturally divides itself into five phases namely:

(a) The preliminaries, which include

(c) The construction, which begins with the impressions.

(d) The installation or insertion of the appliance, including such necessary adjustments as will enable the denture to function satisfactorily.

FIG. 0



A Sheet for Designing Partial Dentures

A pad of paper design sheets, bearing a plan of the fourteen upper and lower teeth; and upon its fly leaf, among other things, the details regarding the steps in design, is admirably suited for working out Partial Denture designs. Red, orange and black pencils (or draftsman's inks), representing respectively, vulcanite metal, and the outlines are used for developing the designs on the design sheets which are issued by the Detroit Dental Manufacturing Co., Detroit, Michigan. 1. shows the pad; 2. a sample design sheet.

such features as the placing of the mouth in a state of health, the choice of the appliance to be used, and the gathering of all data which will bear upon the subsequent design of the denture.

(b) The design, in which the plan of the whole denture is scientifically worked out, based upon this data, and with specifications if necessary.

(e) The maintenance, including provision for the preservation (1) of the adjacent structures in health and (2) of the appliance in proper working condition. This preservation may require repairs, or such readjustments as rebasing, or similar; and may also require, in certain cases, for a time at least, periodic inspection of the adjacent tissues.

The construction of the denture, being based upon the design, with its preliminaries, the first and basic step in construction, namely, the manner of taking the impression, should in each case be partly governed by the type of denture which is designed and by the manner in which the proposed dentures will be supported in the mouth.

(a) the outline of the saddles and (b) their connecting parts, directing the load to the mucosa; (c) retention and (d) location and choice of the occlusal rests (if these are used), directing the load to such remaining teeth as are used for this purpose.

By this or other suitable means of making a design the picture showing the

FIG. 1

ALL SYMMETRICAL COMBINATIONS OF THE POSTERIOR TWELVE TEETH										PLATE 100
1	9	17	25	33	41	49	57			
2	10	18	26	34	42	50	58			
3	11	19	27	35	43	51	59			
4	12	20	28	36	44	52	60			
5	13	21	29	37	45	53	61			
6	14	22	30	38	46	54	62			
7	15	23	31	39	47	55	63			
8	16	24	32	40	48	56	64			

Illustration showing all symmetrical combinations which are possible between the posterior twelve teeth. In each case the four anterior teeth remain constant to complete the picture. The illustration is for the purpose of showing cases in which (a) root, (b) mucosa and (c) a combination of root and mucosa support are indicated in partial denture restoration.

2. PARTIAL DENTURE DESIGN AND THE IMPRESSIONS

The ultimate support of the load which a partial denture receives during mastication may be said, in a general way, to be distributed in three different ways, namely: (a) principally to the mucous membrane lining of the mouth; (b) principally to the remaining teeth or roots; (c) to a combination of these two.

Designs of cases which are not evident on inspection may be worked out on a chart (Fig. 0) in four stages, which are

manner of support should be clearly in the mind of the dentist before any decision as to the manner of securing the impression is reached.

3. IMPRESSIONS AND THEIR REQUIREMENTS FOR ROOT-SUPPORTED PARTIAL DENTURES

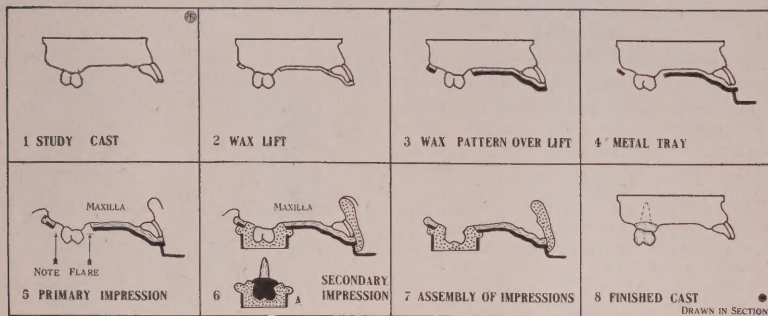
The main requirements for an impression for this type of denture, such, for example, as might be chosen under ordinary conditions for Fig. 1, squares 7, 11, 12, 23, 27, 28, and which imply

spaces not more than the mesio-distal diameter of two teeth in length, are those of ease and rapidity of manipulation together with accuracy of impression of the parts at rest. It is proposed that the impression methods now in use are, on the whole, fairly satisfactory, namely, the various uses of plaster, self-separating plasters, or, in skilful hands, modeling compound (sectional or non-sectional

4. IMPRESSIONS AND THEIR REQUIREMENTS FOR MUCOSA-SUPPORTED PARTIAL DENTURES

In addition to the foregoing, the main requirements of an impression for this type of denture, such, for example, as might be chosen under ordinary conditions for Fig. 1, squares 16, 39, 40, 47, 48, 55, 56 and 61, in which single teeth or groups of teeth are separated by empty

FIG. 2



The primary-secondary method for cases for which mucosa support is planned in the partial denture, with the various stages shown in right elevation. The plan of this condition may be seen in Fig. 1, square 48.

(1) Study cast in plaster from an approximate modeling compound impression.

(2) Cover the outline of the proposed tray with one or more thicknesses of base-plate wax to allow room in the tray for a proper amount of impression material. This base-plate wax is hereafter referred to as a *lift*.

(3) Over this lift the wax pattern for the special tray is formed, without stretching.

(4) A tin tray with a handle is cast in molding sand (calcar), with perforations for the remaining teeth. This casting can be done by an assistant in about ten minutes.

(5) A modeling compound primary impression is taken, muscle trimmed and post-dammed as required, and flared around the perforations.

(6) The primary impression is finished and held in place by adhesion while the secondary impressions in plaster are taken. Should a metal tooth or teeth be desired, it may be made here, as in 6 A. The illustration shows a fusible metal tooth with a Kerr artificial root-end.

(7) The *primary* and secondary impressions are removed from the mouth and assembled, ready to pour.

(8) Finished cast, in stone, with (as shown) or without a metal tooth.

methods) separately or in combination, carried to place upon the various stock trays now on the market. Two later developments will be considered in this series. (Sections 40 and 41) namely the Roach method of sectional plaster impressions; and also the use of a new material having a gelatin base, for which is claimed the property of springing out of undercuts and then springing back after removal.

spaces of various widths, greater than the mesio-distal diameter of two teeth, are that the impressions be made similar to those for full dentures, including a degree of compression, muscle trimming, and post-damming. An additional requirement, especially in this type of case, is the elimination of the difficulty of the removal of the plaster where isolated teeth and groups of teeth incline in various directions away from normal.

5. STAGES IN A PROPOSED IMPRESSION TECHNIQUE FOR MUCOSA- AND COMBINATION-SUPPORTED DENTURES

Using the standard impression methods, somewhat modified, and the standard materials, the writer proposes the following stages (Fig. 2):

(A) An approximate impression in modeling compound, followed by a plaster cast, upon which the dentist outlines a tray suitable for the case.

(B) The tray may be either (1) a wax pattern for a special tray, to be subsequently cast in commercial tin, having suitable perforations for the remaining teeth or groups of teeth, or (2) a stock tray similarly prepared with perforations.

the remaining teeth or groups of teeth left exposed by the perforations, which includes the undercuts. After this plaster has set, these secondary impressions are grooved and broken apart, the primary impression is then released, and the primary and secondary impressions are assembled.

Figure 2 illustrates a detailed consideration of each of these steps.

6. COÖPERATION OF ASSISTANTS

That this plan lends itself readily to the coöperation of assistants and the consequent reduction of chair-side time and other attendant advantages, may be seen from the general plan of coöperation outlined below.

<i>Dentist</i>	<i>Assistant</i>
(1) Approximate impression in modeling compound, for a study cast or casts.	(2) Making the study cast or casts from impression.
(3) Designing the denture, and outlining the tray in pencil on the study cast.	(4) Making the wax pattern, returning it to the dentist to try in the mouth, if desired, casting the tray, and preparing it for the impression.
(5) Taking the primary and secondary impressions.	
<i>Dentist and Assistant:</i>	
(6) Making the cast from the impression, as specified by the dentist.	

(c) A *primary* impression of the mucosa in compound, not including the undercuts (with or without plaster wash), or in plaster, and with such muscle-trim, post-dam or other peripheral manipulations as may be desired.

(d) With the *primary* impression held in the mouth by adhesion, or by tragacanth solution if necessary, *secondary* impressions in plaster are taken of

Obviously this general plan is subject to modifications, as required by the case under consideration, as face-bow registration and mounting of the study casts on the articulator, or cases in which preliminary work is required upon the remaining natural teeth after design is completed, or cases in which the modified stock tray may be used instead of the special tray, or similar.

Impressions for Mucosa-Supported Partial Dentures—the Study Casts and the Tray

7. TAKING THE IMPRESSION FOR THE STUDY CAST (BY THE DENTIST)

This may be done, using any of the excellent stock trays and modeling compounds at his disposal.

It is conceivable that, in certain cases without undercuts or with slight undercuts which will not affect that part of

the impression which relates to the future denture, no further impression will be required. That this condition is exceptional hardly need be mentioned here.

This preliminary impression having been completed, it is handed over to the assistant for the completion of the study cast.

8. THE PRIMARY TRAY

Reference to Fig. 2 will indicate the reason for the first essential, namely, perforations or openings in the tray around each tooth or group of teeth which will allow a clear space of from 5 to 8 mm. around each tooth or group of teeth for, among other reasons, ease of insertion and removal of the primary impressions, and also, upon the completion of the primary impression to allow sufficient room for the easy entry of the

FIG. 3



Modeling compound impression for study cast.

plaster of the secondary impression between the primary impression and the tooth or teeth, and for sufficiently broad area of fracture for accurate reassembling after its removal from the mouth.

Hence the general outline of the primary tray is made on the cast as though no teeth were present. Then a further outline is made for the perforations required for the particular case under consideration.

9. UNDERCUTS VARY WITH THE PATH OF WITHDRAWAL OF THE PRIMARY IMPRESSION TRAY

It must be kept in mind that the direction in which the impression should

be withdrawn, depends upon the presence of undercuts.

For example, in the cases shown in section Fig. 5, with the upper right posterior teeth in position, and all others removed;—should the impression be withdrawn parallel with the long axes of the teeth, there would be two long undercuts at the right and left gingival margins respectively of these natural teeth.

On the other hand, should the outline of the primary tray and of the impression terminate at the buccal cusps of these teeth, and the subsequent impression drawn off diagonally, the lingual undercut would then cease to exist, and the buccal undercut could be taken in another section, as shown in Fig. 51 and also Fig. 50, section 2.

Hence, it is advisable while outlining the tray, to study the case and select the most favorable path of insertion and removal for the impression.

10. STEPS IN OUTLINING THE PRIMARY TRAY (BY THE DENTIST)

For the mucosa-supported partial dentures, compound is preferred for the impression, but for those parts of the impression where there are undercuts, plaster is preferred.

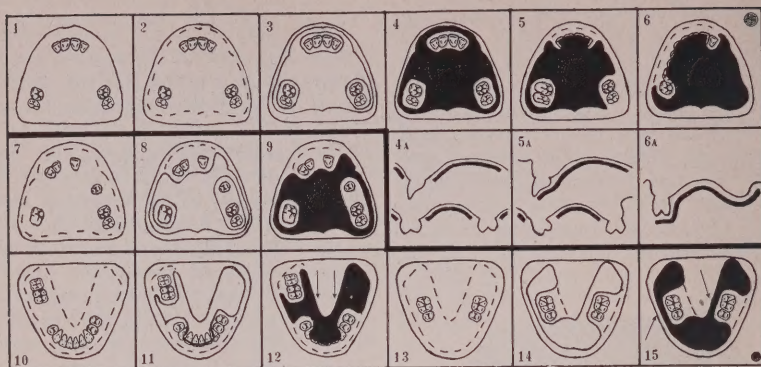
Therefore, in constructing the tray, perforate all parts which, among other things would otherwise cover undercuts.

The following are the directions for outlining the tray; the outlining is done on the study model:

Step 1. General outline of the tray. Sketch the tray tentatively, as if there were no teeth present.

Step 2. Modification of general outline by perforations. Sketch perforations for plaster secondary impressions so that (a) all undercuts are exposed; in addition to undercuts, perforations may also be used for (b) convenience in manipulation (Fig. 4, square 5), and (c) for a plaster secondary impression for a fusible metal tooth (Fig. 2, square 6A and 8) or (d) for teeth carrying clasps or other direct retainers, or (e) for any other condition which calls for part of the impression in plaster.

FIG. 4



Outlining the tray on the study cast.

- (1) Study cast ready for outlining the upper tray.
- (2) Outline of the tray, first step showing the tray outlined as if *no* teeth were present.
- (3) Outline of the tray, second and third steps, showing three closed perforations, allowing about 5 mm. open space around each group of teeth.
- (4) Wax pattern of tray outlined in square 3.
- (4A) Wax pattern of tray in square 4 shown in longitudinal and transverse sections, showing space for the impression material made by the wax lifts (wax lifts not here shown).
- (5) Wax pattern showing a variation from that in square 4; because of leaning teeth the right posterior perforation is enlarged and because of a buccal alveolar undercut the left posterior perforation is an open one. For convenience, wax is carried to the incisal edge of the anterior teeth (half-perforation).
- (5A) Wax pattern of tray in square 5, showing longitudinal and transverse sections, indicating enlarged perforation for a leaning tooth, an open perforation for an alveolar undercut, and half-perforation, exposing the labial surfaces only of the incisors, for convenience.
- (6) Wax pattern for upper impression tray, with the upper anterior five and the upper right posterior four teeth remaining. The tray is carried to the buccal cusps for convenience (half-perforations); open perforations are used around the molar and lateral, so that fusible metal teeth may be used if desired.
- (6A) Transverse section of wax pattern of tray in square 6.
- (7) Outline of upper tray, first step, study cast.
- (8) Outline of the tray, second and third steps, with two closed and one open perforation. Note single closed perforation inclosing a single tooth and a group of teeth, which is preferable over two separate perforations when the space between them is one tooth in width. Note enlarged closed perforation for molar leaning mesially.
- (9) Wax pattern from outline in square 8.
- (10) Outline of lower tray, first step on study cast.
- (11) Outline of lower tray, second step, two open perforations and one half-perforation. (Tray carried to incisal edge of incisors.)
- (12) Wax pattern of tray in square 11.
- (13) Outline of lower tray, first step on study cast.
- (14) Outline of lower tray, second and third steps, two open perforations, one looking to the lingual, and one looking to the buccal, as would be required for an alveolar undercut, leaning teeth, or similar condition.
- (15) Wax pattern from outline in square 14. Note reinforcements are required where arrow points to narrow parts.

Three kinds of perforations are proposed:

(A) A *closed perforation* is an open-

ing in the impression tray which completely surrounds a tooth (Fig. 4, square 9, right molar), or group† of teeth (Fig.

* See description of the lift paragraph 12.

† In the text a group of teeth means adjoining teeth.

4, square 4), or both (Fig. 4, square 9, the left bicuspid and the two molars), at a sufficient distance to allow for a secondary impression.

(B) *An open perforation* is a space in the impression tray only partly surrounding a tooth (Fig. 4, square 12, lower right bicuspid), or a group of teeth (Fig. 4, square 12, lower right molars). Open perforations may look labially (Fig. 4, square 9), or lingually (Fig. 4, square 15), or buccally (Fig. 4, squares 5, 6, 12 and 15), or distally (Fig. 4, square 12, right molars).

(C) *The half-open perforation* is the same as the open perforation, except that it covers particular portions of the tooth or teeth required, namely, the lingual surfaces of the anteriors (Fig. 4, square 5), and the lingual and occlusal surfaces of the posteriors (Fig. 4, square 6). *Undercuts which prevent the removal of the primary impression* (usually in a diagonal direction) must not be present if this is used.

Leaning teeth also require a greater space under their leaning surfaces. All perforations must be made so that the future tray may be withdrawn and inserted readily.

11. THE BASIC PRINCIPLE OF TRAY OUTLINE

To sum up, it may be seen that the underlying principle in tray outline is simply this: Outline the tray on the study cast tentatively to full denture tray outline, and then modify this outline by sketching perforations or openings in the tray *where plaster is desirable* in the impression, for such reasons as undercuts (about the teeth or in the alveolar ridge) or for the making of metal teeth in the cast, or for convenience in manipulation, or for any other cause for which the qualities of plaster are desirable.

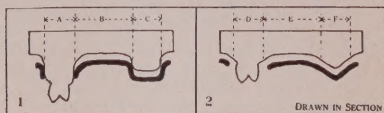
12. MAKING THE WAX "LIFT" WHICH PROVIDES SPACE IN THE TRAY FOR THE IMPRESSION MATERIAL (BY THE ASSISTANT)

Should the wax pattern of the future tray be now made direct to the study cast according to the outline upon it, it

may readily be seen that a tray cast from this wax pattern would not, under ordinary circumstances, allow a uniform space for the impression material. Hence there is, with the exception of cases without marked contours (see Fig. 5), the necessity, as the next step, of adding one or more thicknesses of base-plate wax to enlarge the future tray so that there will be space for that thickness of impression material.

The primary essential in the manipulation of the wax for the lift is that of uniformity of thickness. Hence it is

Fig. 5



The need of the wax lift increases with the abruptness of the contour of the study cast, as shown above.

Both figures show wax patterns of impression trays. Square 1 shows a wax pattern in which the contours are such that there is no space between the tray and the tissue of the mouth for impression material where the contours are abrupt. This is a case which demands a lift.

Square 2 shows an example of a case where the contours are not abrupt, and consequently the impression material is distributed more evenly. This is a case in which a lift may be omitted, if desired.

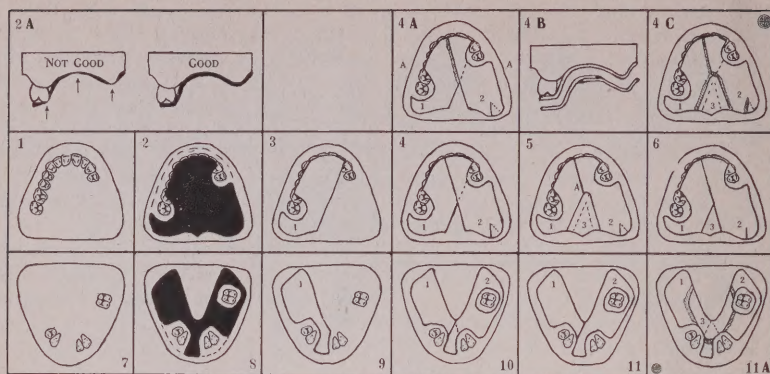
not wise to warm the wax and to press it into position in the ordinary way with the thumb and finger, because this will ordinarily result in the material being stretched both over the high and low places in the study model, as in Fig. 6, square 2A. Rather it is better to cut a slit in the wax where it buckles, and to overlap the wax, and then to reduce it to uniform thickness.

In a similar manner, where the wax tends to stretch thin, also cut a slit and let it draw apart, afterward inserting a triangular piece of wax to fill the space.

A standard procedure in adapting the wax for the lift is proposed as follows:

After slightly warming a sheet of base-plate wax, cut off with the shears about

FIG. 6



Making the wax lift and the wax pattern for the tray.

As noted in the text, both are made of base-plate wax, and the wax lift, if needed, is made, using pieces of wax butted together to secure uniform thickness, while the wax pattern for the tray (fitted over the wax lift) is made of pieces of wax lapping over one another, so that it is reinforced as required.

MAKING THE WAX LIFT

- (1) The study cast upon which a lift and also a tray pattern is to be made.
- (2) The form of completed lift.
- (2A) Showing why a lift, to secure uniform thickness of wax on a study cast with even fairly abrupt contours, must be made in pieces, and not of a single piece stretched over these contours. Left-hand drawing is a section of the lift shown in square 2, made of a single piece of base-plate wax. Note the stretched portions, indicated by arrows. Right-hand drawing shows the same lift made with pieces of base-plate wax butted together with uniform thickness as previously described.
- (3) Piece No. 1 of base-plate wax applied. The open perforation is also cut at the same time as the wax is cut to the peripheral line of the tray.
- (4) With piece of wax No. 1 in position, piece No. 2 is laid on, the dotted line showing where they cross. The wax which lies over the contour over the tuberosity is then slit and folded over and the open perforation is also cut.
- (5) Piece of wax No. 2 is cut along the overlap, as shown in square No. 4A and butted at A. Piece of wax No. 3, while warm, is pressed over the V-shaped space. This indicates on the wax the shape of the space, for convenience in cutting.
- (6) Piece of wax No. 3 is cut to shape and then fitted into the V-shaped space. The lapped section over the tuberosity is then cut along the laps, which cuts off and releases the second thickness, resulting in a lift of uniform thickness.
- (7) Study cast for which a lower tray pattern is to be made.
- (8) Form of completed lift.
- (9) Piece No. 1 of base-plate wax applied for a lift.
- (10) With piece of wax No. 1 in position, piece No. 2 is laid on. The dotted line shows where they cross. The open and closed perforations are cut as shown.
- (11) Piece No. 2 is cut along the overlap and butted to piece No. 1, giving a lift of uniform thickness.

MAKING THE WAX PATTERN FOR THE UPPER TRAY

- (3) If a lift is required, it should be on the study cast (note that no lift is shown here). The shaping of No. 1 piece of wax for the pattern of the upper tray is the same as for the lift.
- (4) With piece No. 1 in position, piece No. 2 is laid on. The dotted line shows where they cross. The marked contour over the tuberosity is cut and folded over, the same as for the lift.
- (4A) Different from the lift, a lap joint, stiffening the future tray around the future handle, is used. With a hot spatula the lap joint is sealed together on both sides, only one of which is here shown.
- (4B) Cross-section of cast, lift, and tray at A-A (as shown in square 4A), showing seal of lap joint on both sides.

- (4C) Completed pattern, showing sealed lap joints on one side; the position of the sealed lap joints on the other side is shown by dotted lines.

MAKING WAX PATTERN FOR THE LOWER TRAY

- (9) If a lift is required, it should be on the study cast (no lift is here shown). The shaping of No. 1 piece of the wax tray is the same as for the lift.
- (10) With piece of wax No. 1 in position, piece of wax No. 2 is laid on. The dotted line shows where they cross. The open and closed perforations are cut as for the lift, as shown.
- (11A) As in square 4A, pieces Nos. 1 and 2 are sealed together with a lap joint. Note a further reinforcing piece No. 3 is laid on and sealed to give the necessary stiffness to the future tray.

$1\frac{1}{2}$ inches (more or less, according to the size of the cast), which gives a piece of wax 3 inches by $1\frac{1}{2}$ inches in size.

This piece of wax is laid diagonally across the cast as in Fig. 6, squares 3 and 9, and is peripherally trimmed to the tray outline. A second piece of the same size is laid diagonally across the other half of the cast, overlapping the first piece anteriorly, as in squares 4 and 10.

A wax knife is then pressed in along the overlap, which will cut off and release the second thickness, allowing a butt joint, as in Fig. 6, squares 5 and 11.

Should any remaining areas require to be covered, as in the V-shaped space in Fig. 6, square 4, a piece of wax is warmed and pressed over it. This will result in a print on this wax of the outline of the space, as in Fig. 6, square 5. Then cut it out and fit it in, as in Fig. 6, square 6.

13. CASES IN WHICH NO WAX LIFT IS REQUIRED

Reference to Fig. 5 will indicate the reason why the wax lift may be omitted in cases in which the contours are not marked. A simple and practical method of ascertaining this is to make the wax lift (leaving the lap joined in case it is used for the tray pattern), trimming it to the shape of the tray, then lifting it off the study cast about the thickness of the impression material. If there is ample and fairly uniform space for the impression material, or if, with a little manipulation, it may be made so, then the wax lift itself may be reinforced and used as the pattern for the impression tray.

14. MAKING THE WAX PATTERN FOR THE SPECIAL TRAY OVER THE LIFT (BY THE ASSISTANT)

By reference to Fig. 6, it will be seen that the process is identical with that for making the lift, except that instead of butt joints, lap joints are used for reinforcement.

For the wax pattern of the tray, the joints are lapped and sealed with a hot spatula on both sides. Reference to Fig. 6 will show that this will result in a reinforced tray at a point where it is most needed, *i.e.*, in the vicinity of the handle and also back of it to prevent spreading of the tray.

At other places where reinforcement is required, an additional thickness is laid on and sealed as in Fig. 6, square 11A.

To finish the pattern for the tray, the edges should be rounded by quickly passing a hot spatula over them and the remaining surfaces made sufficiently smooth so that the sand will readily withdraw from them.

15. MOLDING AND CASTING THE SPECIAL TRAY (BY THE ASSISTANT)

One of the oldest processes known to civilization and one of the most universally used in present manufacturing practice, is proposed for use in the next step, namely, sand casting.

Reference to Figs. 7, 8, 8a, 9, 10 and their accompanying legends will indicate the process, as well as the tools and materials used.

The flask proposed, the Bailey, although designed for a different purpose, namely, for making swaging casts and

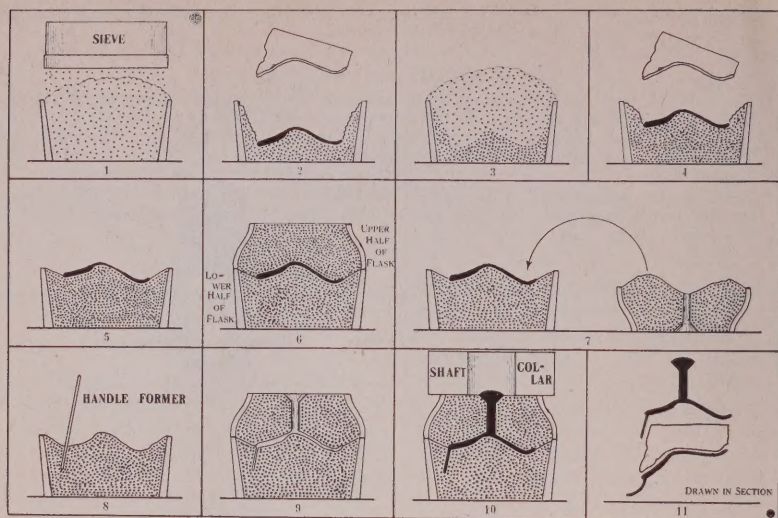


FIG. 7. Molding and Casting the Special Tray

The Bailey molding flask (see Figs. 8, 8A and 9) is used, of which the part with the curved profile will be called the upper half or "cope" and that with the straight profile the lower half or "drag," as indicated in square 6 above. Calcar, a molding compound* suggested by Dr. Gritman for dental purposes and made by The S. S. White Dental Mfg. Co., Philadelphia, is proposed as an admirable molding sand in this work. Another similar material "Dixon's Improved Casting Sand" is made by William Dixon, Inc., Kinney St., Newark, N. J., is also recommended.

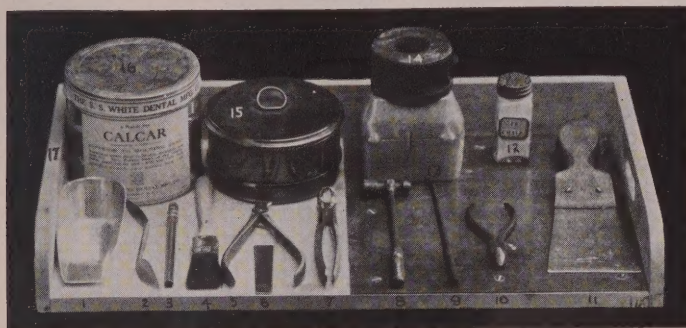
- (1) Sifting the sand with a 10-mesh sieve (Figs. 8 and 8A) into the lower half of the flask.
- (2) The study cast with the wax lift and pattern, all dry and well dusted with French chalk, are pressed into the lower half of the flask with sufficient force for the sand to cohere firmly and also as far as possible, so that the edge of the pattern is equidistant from the edge of the flask. With the finger, or with the end of the brush handle (Figs. 8 and 8A) the sand is well packed around the edge of the cast, and the cast, lift and pattern are removed. The picture shows the cast and the lift removed, but the pattern yet to be removed. Note the increased density of the sand.
- (3) The pattern being removed, additional sand is sifted in.
- (4) The process in square 2 is repeated until —
- (5) The edges of the wax pattern are approximately level with the top of the lower half of the flask, at which time the sand is finally compressed, leveled and smoothed with the thumb and finger, and the whole is well dusted with French chalk, the separating or "parting" medium. The use of China silk as a parting medium is suggested by Dr. H. H. Cummer, Toronto.
- (6) The upper half of the flask is then fitted on; sand is sifted and packed in, and the top is leveled with the scraper (Fig. 8).
- (7) The flask is then inverted and the lower half is lifted off the upper (because the sand is less liable to fall out of the lower than out of the upper, when inverted). Remove the wax pattern with a pen-knife; a sprue is made in the sand in the upper half of the flask with the $\frac{1}{4}$ -inch cork borer, Figs. 8 and 8A, which in its upper part is given a funnel shape for the reception of the metal by rotating the heart end of the "Heart and Spoon" molder's tool (Figs. 8 and 8A) in it from below.
- (8) With the handle former (Fig. 8), a depression is made on the lingual side of the mold at the position in the mold at which the handle is desired. For a narrow handle the $\frac{1}{8}$ inch cork borer may be used (see Figs. 8, 8A and 11).
- (9) To reassemble the halves of the flask, after the pattern is removed, the sprue and handle molds made, and any adjustment required in the sand completed, the lower half of flask is fitted to the upper half.
- (10) A ring-shaped weight, of about three pounds, with flat ends (an ordinary shaft collar is suggested, Figs. 8 and 8A), is laid on to prevent the halves of the flask from separating during casting. The picture shows the mold immediately after casting.
- (11) Upper part of the drawing, casting after sand is dusted off. Lower part of the drawing shows the casting with sprue cut off and handle bent, ready for the next step.

* Said to be composed of marble dust and glycerine.

dies for swaged metal bases, may be used. A V-shaped file cut, passing from the upper to the lower halves of the flask, as shown in Fig. 8 (13) and 8A (4), will assist the operator to keep the halves

of the flask in register while replacing them. At all stages of the process, however, it is safer to keep the upper half on top, except for purposes of separating when the whole flask is inverted, as in

Fig. 8



Tools and materials for molding (see Fig 8A for manufacturer's illustrations).

- (1) Small aluminum scoop.*
- (2) "Heart and Spoon" 1 inch, a standard molder's tool.*
- (3) Cork borer,† steel, set of three ($\frac{1}{8}$ inch to $\frac{1}{4}$ inch), No. 3270, A. These are thin steel tubes, nested, which will readily cut sprues in the molding sand.
- (4) Flat chisel varnish brush, one inch,* for dusting off the mold or pattern.
- (5) Contour pliers (Prothero) for making adjustments in the casting.
- (6) Handle-former. A piece of brass plate 16,* B. & S. gage, 3 inches long, $\frac{3}{4}$ inch at one end and 1 inch at the other. The $\frac{3}{4}$ inch end is filed to a double chisel edge, so as to cut its way into the sand. Later illustrations show the use of the cork borers for this purpose.
- (7) Discarded forceps, or similar instrument, useful for picking up warm castings.
- (8) Light hammer.*
- (9) Small mouth blowpipe, with small end cut off.† Useful for blowing loose sand from the mold or pattern.
- (10) Angle- (or side-) cutting pliers.*
- (11) Kitchen scraper.*
- (12) Shaker for French chalk, with small perforations similar to those in a pepper shaker.* An improvement on this is shown in Fig. 15A.
- (13) Bailey flask largest size No. 2 (3 inches by 3 $\frac{1}{4}$ inches).
- (14) Solid set safety collar (for steel shafting 1 $\frac{7}{16}$ inches), iron, faced.‡
- (15) Cement sieve, No. 12084, with cover, No. 12102, 5-inch, 10-mesh, woven wire.
- (16) Calcar, three pounds (S. S. White).
- (17) Bake board, for convenience in small laboratories, one-half of which is covered (for molding upon), with 16 B. & S. sheet brass, as shown.

In addition to the above, a safety-razor blade, preferably mounted on a handle,§ is useful for cutting sprues in molds for lower trays, which is a slightly different process from that of cutting sprues on uppers (Fig. 9). A long, slender, dental instrument (a discarded explorer, for example), sharpened to a point, is useful in making auxiliary sprues, as in Fig. 10, squares 11 and 12. This may be seen, Fig. 8A.

* Any good hardware store.

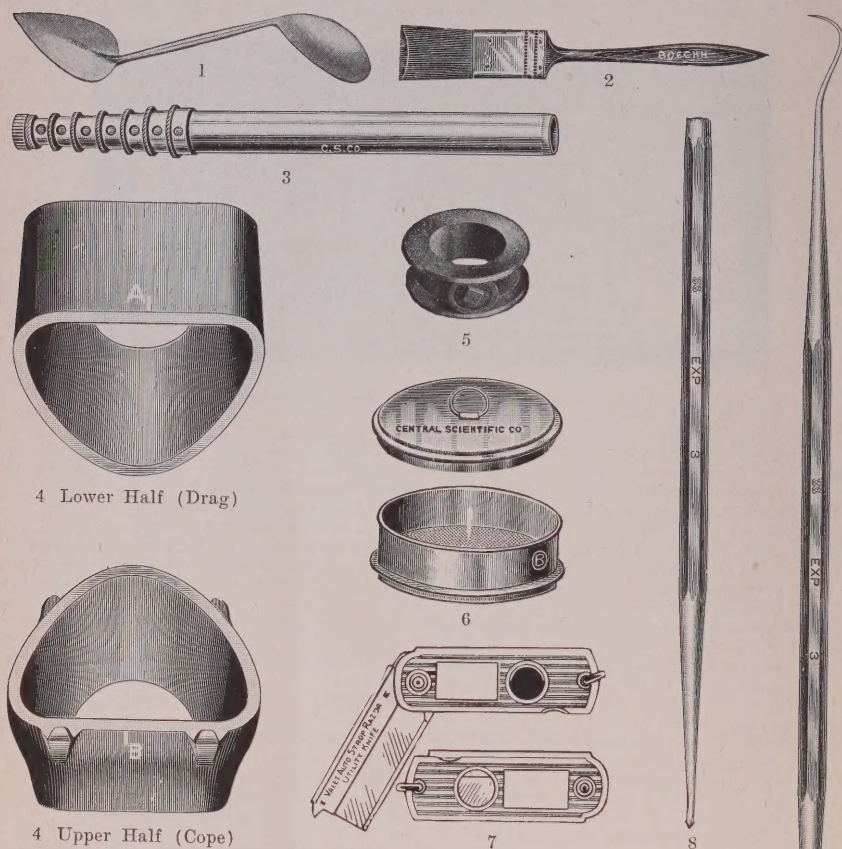
† Any laboratory or school supply store. The catalog numbers are those of the Central Scientific Co., 460 East Ohio St., Chicago, Ill., U. S. A., and also 119 York St., Toronto, Canada.

‡ Any mill supply or machine tool store, as the Fairbanks-Morse Co., various American cities and Toronto, Canada.

§ The "Valet-Autostrop Utility Knife" admirably serves this purpose, Fig. 8A.

Fig. 10 (1 and 2). The reason for this is that the sand more readily falls out of the curved upper part of the flask than out of the straight-sided lower part. The sand should therefore be, if anything, more firmly packed into the upper half (cope) of the flask than in the lower half (drag).

FIG. 8A



Manufacturer's illustration of some items in Fig. 8

- (1) Heart and spoon, 1-inch Burr-Damascus Tool Co., Detroit, Mich.
- (2) Flat chisel brush, Boeckh Brush Co., Toronto, Can.
- (3) Cork borer. This illustration shows a set of seven. No. 3270-A (Central Scientific Co., Chicago) is a set of three suitable for this work.
- (4) Bailey Flask, largest size, S. S. White Dental Mfg. Co., Philadelphia (note V-shaped file cut, described in the text).
- (5) Solid set safety collar 1 7/16 inches (for steel shafting), Canadian Fairbanks Morse Co., Toronto.
- (6) Cement sieve No. 12084 with cover No. 12102, 5-inch, 10 mesh, Central Scientific Co., Chicago.
- (7) Valet Auto Strop Utility Knife, Auto Strop Razor Co., Toronto.
- (8) A vent former made from a discarded explorer such as shown on the right.

Calcar is an excellent molding material and in spite of the frequent use of French chalk (the parting or separating medium), lasts through scores of castings, which is partly due to the low fusing-point of commercial tin. The molding sand prepared by Dixon (Fig. 8) has similar properties.

The process of molding is described in the legend under Fig. 7 and the tools and materials used under Figs. 8—8A.

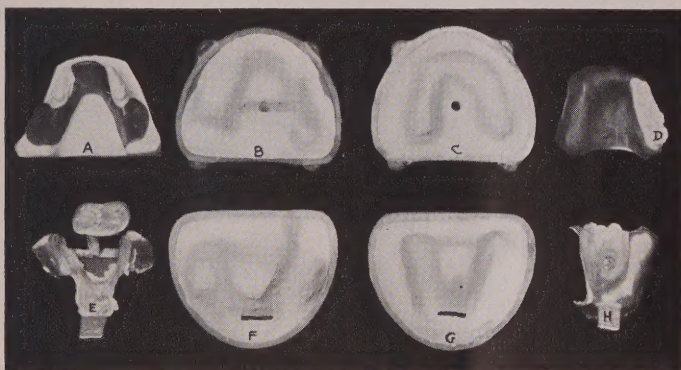
Commercial tin, fusing at 442°F., is entirely suitable for casting. Many

ing, this film should be skimmed off away from the pouring lip of the ladle.

After pouring, the metal will freeze in a moment or two, and the sand may be brushed off dry, and the tray may be picked up in the bare fingers by its handle. It is safer not to cool the casting in water, because the wet sprue, after being cut off, may unthinkingly be returned to the still molten metal in the ladle, which is dangerous.

Should it not be convenient for the dentist or his assistant to cast these

FIG. 9



- A, Difference in molding the lower and the upper tray: C and G, upper and lower halves of a flask containing a mold for an upper tray from a wax pattern at D; note sprue and handle molds cut in the main mold. B and F, Upper and lower halves of a flask containing a mold for a lower tray from wax pattern at A. Note sprue and handle molds, also V-shaped passages cut with a safety-razor blade (Fig. 8A, 7) in the sand, on both sides of the sprue, connecting with the mold. Were these not cut there would be no communication between the tray mold and the sprue (E). E, Lower casting with sprue not yet removed; H, upper casting with sprue removed.

castings may be made from a pound, and used trays are readily remelted. Properly reinforced, especially in lowers around the perforations (Fig. 6-11A), it is sufficiently rigid for the purpose of impression taking, and sufficiently pliable for adjustment to the tissues. Its low fusing-point makes it convenient for laboratory use.

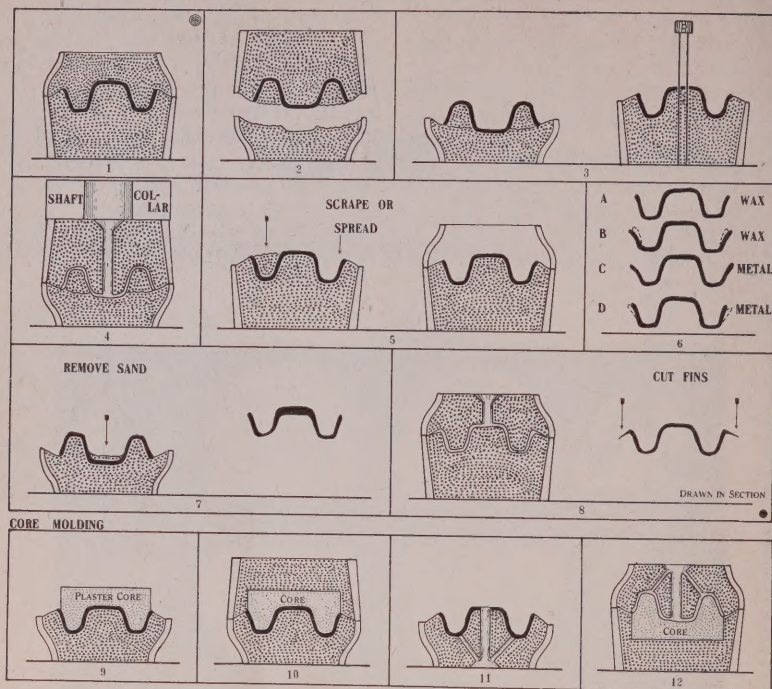
In casting the tray, the metal should be sufficiently hot (especially for the larger areas in uppers), so that a film is plainly visible on the surface of the molten metal. Immediately before pour-

trays, the work may be readily done in the commercial laboratory or, failing this, in a brass foundry, which is carried on by men who are expert in all branches of molding.

16. MOLDING THE LOWER TRAY, SHOWING THE DIFFERENCE IN SPRUES (BY THE ASSISTANT)

A difference in molding the upper tray and the lower is shown in Fig. 9, with accompanying legend, and is that of two short additional sprues, which must be

Fig. 10



Complications in molding

FAULTY PARTING OF THE SAND ABOUT THE PATTERN

- (1) Mold ready to part.
- (2) Faulty parting; inclusion of sand in the pattern. Invert lower half (with pattern on top) on table; loosen both the pattern and the included sand a little by slightly bending the pattern. Then bring the upper half carefully over it by tipping both halves together, then invert, and separate.
- (3) After the tray is invested and separated, pattern and included sand should come on the upper half, because of the loosening in the previous step. Note position of fracture. Before removing pattern, tap it a little with a light hammer so as to consolidate the sand at the fracture. Then remove the pattern.
Note that the sprue is being formed through the lower part of the flask instead of as usually is done in the upper part. This is done so that the fractured pieces of sand are partly held by gravity (square 4). Then place the pattern on the lower half of the flask and use the cork *through* the pattern into the sand, so as to protect the projecting portion of the sand from being displaced outward.
- (4) The mold ready to cast. The metal must be hot, as it must go up and down before filling the mold, and up only at the handle (not shown).
- (5) Another method of treating included sand: Remove the included sand, scrape or spread the pattern, add a larger amount of French chalk parting, replace the upper half and repack the sand.
- (6) Another method: Spread the wax pattern and bend it back in the finished casting.
- (7) Another expedient: If a small quantity of sand is included on the side *away* from the mucosa, it may be brushed off after separating and the cast made, which will be thick in the corresponding location.
- (8) Fins are caused by the sand breaking off at the periphery of the pattern on removal from the sand and may be easily cut off after the casting is made.

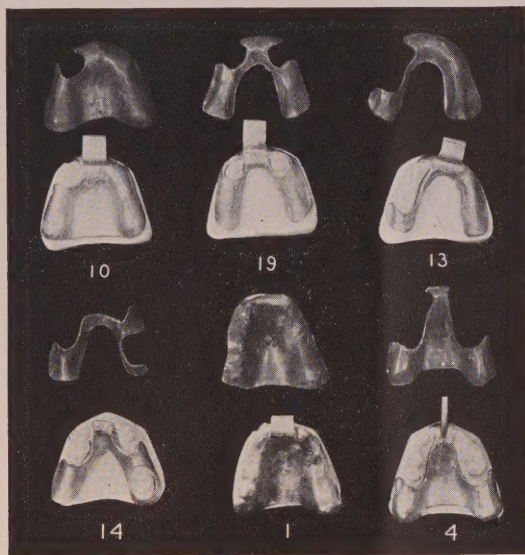
CORE MOLDING

- (9) Take the tray and pour a plaster core on the mucosa side. Because of the bulk of this core and the contour of the upper half of the flask, the first molding should ordinarily be done in the upper half of the flask rather than in the lower, as in Fig. 7.
 - (10) Both halves molded, core and pattern still in place.
 - (11) Upper half, bearing core, is here removed. The sprue is made through the pattern. Note auxiliary sprues made with slender instrument (see legend, Figs. 8A, 8) to help the casting over the high part of the core. Note that these are recommended for core and not for similar all-sand mold (square 4), because the metal will not flow as readily over a plaster core as over sand.
 - (12) Ready to pour (after weight is placed on top, as in square 4).
- NOTE:—Another method of core molding, using the lower half of the flask only, is shown. Fig. 28A.

BREAKING SAND AROUND THE CORK-BORER

The cork-borer should, if possible, be pressed into the sand into a depression, as in Fig. 7, square 8, Fig. 9, F and G. Should it be necessary to make these in an elevation of sand, it should be done by passing the cork borer, or the handle-former *through* the wax pattern as shown in squares 3 and 11. Should this precaution be accidentally omitted and the sand become displaced, all that is ordinarily necessary is to replace the pattern, tap it, thereby reforming the sand underneath, and then to readjust the handle or sprue mold as required.

FIG. 11



Six wax patterns (upper and third rows) and their study models, bearing finished trays (second and fourth rows).

Note a slight variation in the pictures, between the finished tray and the wax pattern, which is so shown to illustrate variations in the perforations chosen under different conditions. Note also that the $\frac{1}{8}$ inch cork borer has been used to make the handle on No. 4, because of the narrow space available.

cut in the mold to connect it with the main sprue. As may be noted in Fig. 9, a casting of a sprue only and no tray would result if this step were omitted.

As the degree of abruptness of the contours in the pattern, especially if complicated with deep V-shaped recesses, increases, then the difficulty of

molding and the avoidance of fractures in the sand increase.

For such patterns special care should be taken in waxing so as to have smooth surfaces which will readily withdraw from the sand. Also a greater quantity of French chalk is needed which, while detracting from the smooth finish of the finished casting, makes the separating of the mold more easily done.

It is needless to add that the sand must be sufficiently well packed so that it will remain in place during manipulation. If a handful is picked up and compressed in the hand so that it breaks with a clean fracture, some idea of the density required may be gained. In fact, in the experience of the writer, the only limit to overcompression of the sand in this process is that of the safety from fracture of the wax pattern. Care must also be taken in bringing the halves of the flask into register when each half contains a mold, so that the molds do not strike one another and become damaged.

The more frequent complications in molding, with methods for dealing with them, are illustrated in Fig. 10, with accompanying legend.

17. FINISHING THE TRAY (BY THE ASSISTANT)

All edges, other than the perforations, should be rounded off after the fins, if any, have been cut off. The closed and open perforations should be given a flare of 45° for easy withdrawal of the secondary impressions and should be at least 5 mm. from the gingival margin of the nearest tooth, or more if the tooth is leaning.

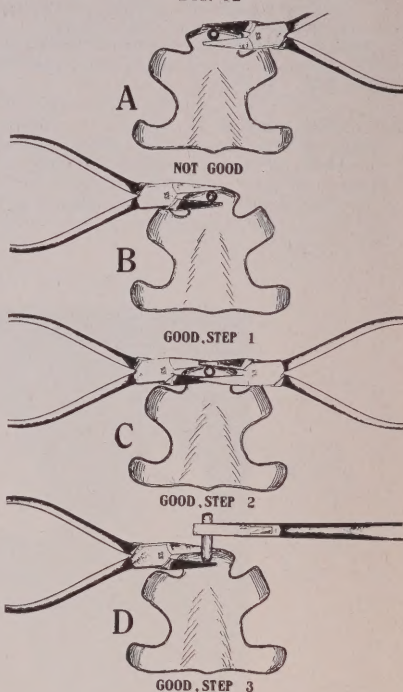
Half-open perforations should be given an edge at right angles to the surface of the tray. The reason is evident for this in Fig. 2, squares 5 and 7.

Holes in the casting may ordinarily be left untouched if a centimeter or less in size. Larger deficiencies may be repaired by soldering a patch of air-chamber metal (lead faced with tin) of 19 gage B. & S., with small scraps of tin,

using ordinary commercial soft soldering paste as a flux.

If at all convenient, it is wise to try the tray in the patient's mouth before the next step is taken.

FIG. 12



Bending the handle for the tray: If a single pair of pliers be used, as in A, to bend the handle, the whole anterior part of the tray may be bent out of shape. Therefore two pairs of pliers are suggested, beginning as at B, with one pair of pliers in the left hand applied to the handle close to the body of the tray; then, as at C, another pair held in the right hand is applied above the first pair, and the handle is bent as at D, without any danger of distortion.

18. BENDING THE HANDLE OF THE TRAY (BY THE ASSISTANT)

In Fig. 7, spaces 8 to 11, it will be noted that the space made in the sand mold which later forms the molten tin into the tray handle, is made either with a flat handle-former tool, as in Fig. 8

(6), or with the 1/8 inch cork-borer, Figs. 8 (3), and 8A (3), the latter making a 1/8 inch rod-shaped handle, but in both cases these instruments are straight—a convenient form for working in sand.

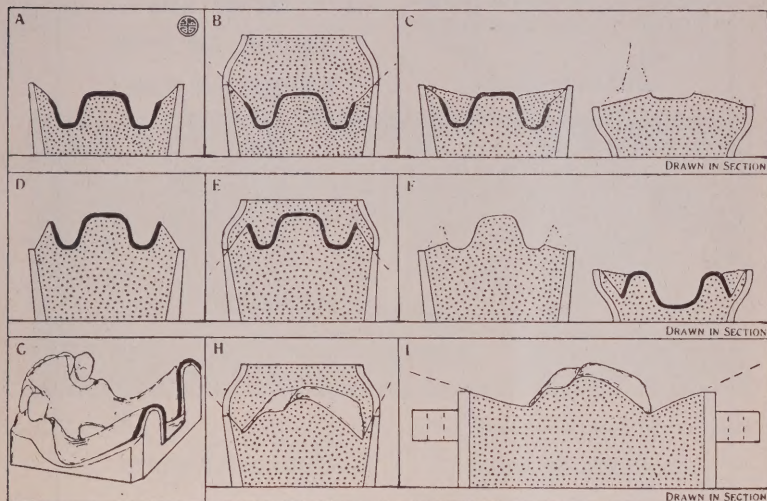
The handle of the cast tray, therefore, when removed from the sand is straight; and if it is not bent, as in Fig. 7, space 11, it would interfere with the lip and teeth during impression taking. The flat cast handle, while less convenient to

19. COMPLICATIONS IN MOLDING

These are due to the following principal causes: (A) faulty parting of the sand about the wax pattern; (B) faulty parting of the sand about the parting surfaces; (C) faulty parting about the study cast due to undercuts.

(A) *Faulty parting at the pattern.* Fig. 10 shows examples of faulty parting or separation between the wax pattern and the sand from the most frequent

FIG. 13



Showing how to avoid faulty parting about the parting surfaces by having the pattern half-way in and half-way out of the drag of the flask, and using, if necessary, a larger flask.

manipulate in the sand than the round handle, is readily bent with the fingers.

But in the case of the round handle, even when a double thickness of metal is used where the handle joins the tray (Fig. 6, spaces 4A, 4B, 4C, and also 11A, lapped joint in waxing the pattern), there is danger of distorting the tray if only one pair of pliers is used to bend the handle.

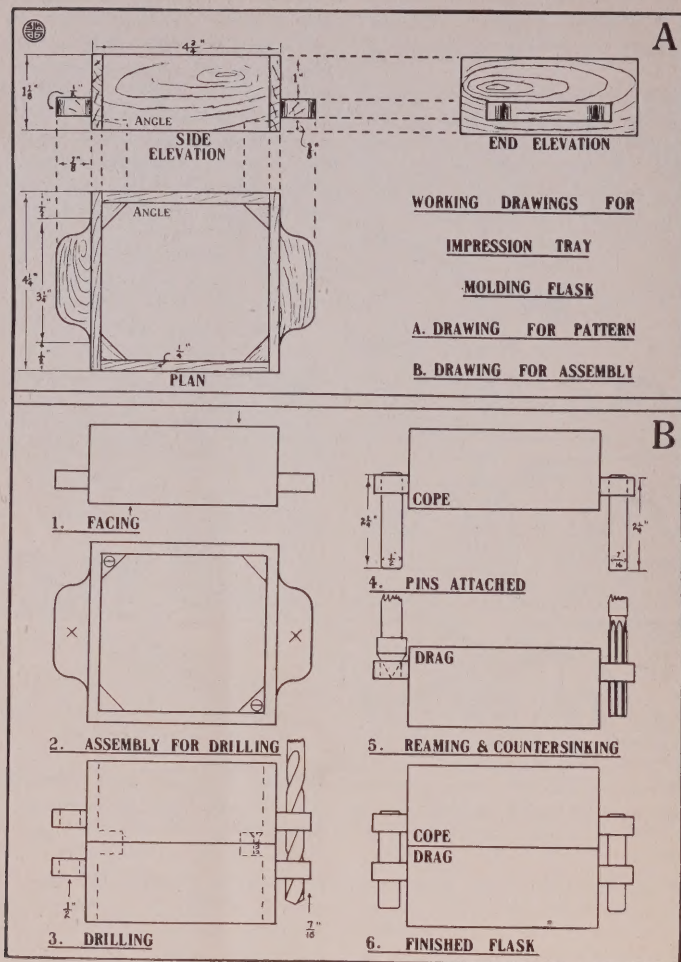
Two pairs of pliers are therefore suggested, a pair to be held in each hand, one pair grasping the handle at a point where it joins the tray and the other to be used for bending, as seen in Fig. 12.

causes, with a remedy for each. It may again be noted that, no matter what complications may arise, the pattern, which is always preserved, is ready for use in remaking the sand mold either partially or entirely.

(B) *Faulty parting about the parting surfaces.* If sand fails to part from an abrupt but smooth surface in wax, then it is much more likely to fail to part from two abrupt approximating surfaces of sand, even when there is interposed a parting medium such as French chalk.

In Fig. 13 it will be noted that the pattern in each case is bedded half-way

FIG. 14



Working drawings for impression tray molding flask:* The upper section of this drawing contains dimensioned sketches of the wooden pattern for molding the flask. Having obtained the pattern from the patternmaker, two aluminum alloy castings are made from it at the brass foundry, and handed over to a machinist for finishing.

The lower section of the drawing shows the steps in order in machining the flask. In the fifth step, namely, reaming and countersinking, the 1/2 inch and 7/16 inch holes are each reamed 1/64 inch larger and a light countersink is given each hole, so that the guide pins may move readily in and out of the drag of the flask.

* The writer desires to acknowledge a valuable suggestion of Mr. C. A. McKenna of the S. S. White Dental Mfg. Co., of Canada, in the design of this flask.

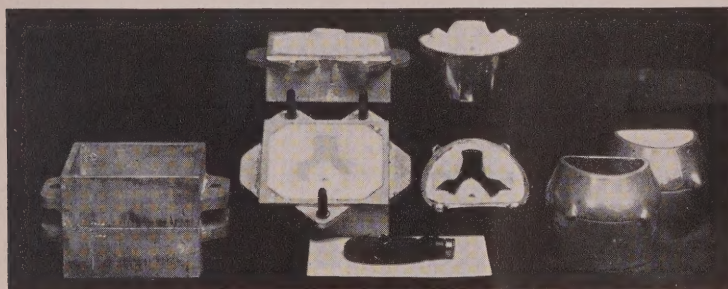
in and half-way out of the drag* of the flask, for the purpose of insuring the easiest possible slope.

In Fig. 13 the mistake is made, in sections A, B, C, of the pattern being too low in the drag, and in sections E, F, G, of the pattern being too high in the drag, with the result that in each case the contours are too abrupt in B, E and H, and the faulty partings occur, as in C and F, as shown by the dotted lines, which represent the desired partings. Note that in F, even if the parting were good, a too fragile ridge of sand would remain.

This same difficulty will arise from a tray pattern too large for the flask, as

A second means to this end, especially when the tray pattern is large, is the use of a flask of larger dimensions than those of the Bailey flask. Working drawings of such a flask may be seen in Fig. 14, from which any number may be made, preferably, from the writer's experience, of commercial aluminum alloy, as in common use in any brass foundry. It will be noted that long guide pins (of unequal diameter to prevent the cope being returned to the drag in reverse relationship) will also assist the operator to bring the cope and the drag together so as not to break the sand. The rectangular bosses which carry the guide pins are

FIG. 15



The impression tray molding flask and the Bailey flask, showing differences between the two as described in the text.

the lower tray pattern shown on the study model in G, also as molded in H, displays too abrupt a parting line. Likewise in E and H, there is insufficient room between the pattern and the wall of the flask to manipulate the sand. Moreover, it may be noted that, with a large flask, as in Fig. 13, I, which is described in Fig. 14, the parting surfaces are less abrupt, even with the bulky pattern shown in G and H.

The securing of this easy slope is the secret of the prevention of faulty partings in the sand, and is done first by having the pattern half-way in and half-way out of the drag of the flask.

also useful as a hand grasp during molding. In Fig. 15 may also be seen a picture of this flask beside a Bailey flask, showing the easier slope in the drag of the larger flask of an actual casting operation as shown in Fig. 13, sections G, H, I.

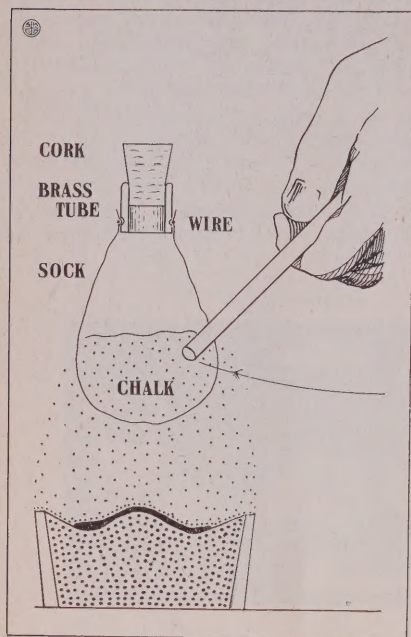
(c) *Faulty parting about the study cast due to undercuts.* The study cast, which is usually made from a simple impression in modeling compound, using a stock impression tray, does not ordinarily present undercut contours, because modeling compound distorts when withdrawn against undercuts.

Should, however, a study cast present undercut contours which seriously disturb the sand mold at the time of withdrawal from the mold (such as in steps

* As already stated, the cope is the upper part of the flask; the drag, the lower.

(2) and (4), Fig. 7), these undercuts may be temporarily filled with wax; or, if it is desirable, one of the undercut

FIG. 15A



An appliance for dusting a uniform film of French Chalk on the surface of a Mold for Separation Purposes.

This appliance is easily made by cutting about 4" from the toe of a discarded silk or rayon sock or stocking and wiring it with copper wire 18 g. to a short length of $\frac{1}{2}$ inch brass tubing, into which a groove has been cut on the lathe to hold the wire. The bag thus made is easily filled through the tube with French chalk after which it is stoppered with a cork.

To use the bag for dusting a film of chalk, hold it above the surface and strike it repeatedly with any convenient instrument and the French chalk will fall as a fine dust upon the surface beneath.

A photograph of this appliance lying upon a square of white paper will be seen in the foreground of Fig. 15.

plaster teeth may be snapped off and subsequently cemented to place, should the cast be needed for further use.

20. OTHER METHODS OF MAKING TRAYS FOR PRIMARY IMPRESSIONS (BY THE ASSISTANT)

For many years descriptions of methods for making special impression trays have appeared in the literature, chiefly, however, for full denture service. Generally speaking, each of these methods, properly handled, will produce the result desired, namely, a properly fashioned primary impression tray for partial denture impression taking.

However, in proposing the foregoing method of casting the tray in sand, the writer has been convinced of its practicability after considerable experiment. A list of the more important of these other methods follows, with a note of comparison with the method proposed here.

(A) Casting impression trays (in each case assuming the cast and the wax pattern of the Tray to be finished):

(1) Tin cast under gravity in split plaster mold. Takes more time (seven minutes against time for the set of two mixes of plaster, and drying out, say, sixty minutes). Figs. 69, 70 and 71.

(2) Tin cast under gravity in split flask, as Watt's flask. Same as (1).

(3) Tin cast under gravity, with or without flask, using disappearing wax pattern in single investment. Takes additional apparatus and longer time. (Investing, drying out investment, say, fifty minutes, against seven minutes.) Pattern is lost and is therefore not available in case of failure of casting, Figs. 72 and 74.

(4) Aluminum cast under pressure, in casting machine, disappearing wax mold. Same as (3), with additional apparatus as required for casting aluminum bases for dentures.

(B) Swaging impression Trays (in each case assuming the plaster or stone swaging cast is ready):

(1) Soft metal swaged in swaging press. These are not, as a rule, as suitable for partial denture impressions as for full denture, because of a lack of stiffness in the narrow widths of metal neces-

sary in a partial tray and the difficulty in adequately reinforcing these narrow strips.

(2) Brass or nickel silver in swaging press. These are entirely suitable, but require a more lengthy process, because of the reinforcing and attaching handle by solder in addition to the actual swaging.

(C) Vulcanizing impression Trays:

Vulcanizing by attaching unvulcanized rubber to the cast by rubber cement, in-

vesting once, then vulcanizing. Consumes more time (investing, vulcanizing, cooling, etc.), also the finished tray may not be as readily bent if desirable.

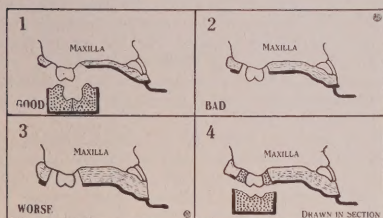
All that is required, however, in this primo-secondary method for partial impressions, is a specially made primary impression tray having the necessary form and qualities. Any of these methods or other methods preferred by the dentist which will give such a tray will result in quite as good a primary impression as the method recommended.

The Upper Impression, Mucosa Support

21. THE PRIMARY IMPRESSIONS, UPPER AND LOWER, MUST BE THIN

Reference to Fig. 16 will illustrate the first essential of the primary impression, both upper and lower, namely, that it

FIG. 16



The primary impression must not be too thick.

From this illustration it is obvious that the impression must be thin so as to well expose the tooth for taking the secondary impression, as in space 1. In spaces 2 and 3, which are wrong because the tooth is not well exposed, the difficulty is, first, to get the plaster of the secondary impression to place, and second, having gotten it to place, to remove it intact. The usual consequence of this error is the fracture of the secondary impression, as in 4, rather than its removal in two pieces and reassembly as in 1.

must be thin, especially at those parts which lie adjacent to the remaining teeth.

It will be noted that to this end the primary tray, the description of which

has just been completed, is made upon a wax lift, which is in turn fitted to the study model, and which provides room for a small quantity of impression material approximately the thickness of a sheet of base-plate wax, about 1 to 2 mm. This thickness of material permits the remaining teeth to be exposed sufficiently, so that it is possible to secure a secondary impression.

Figure 16 is, in part, a repetition of Fig. 2, space 6, but with additional drawings showing the primary impression *too thick*. It may be seen that it becomes difficult, if not impossible, to secure the secondary impression of the remaining teeth when they are partly buried in the primary impression and are not sufficiently exposed to be accessible.

Experience has shown that the most accurate modeling compound impression, and one which most faithfully reproduces all fine detail so important in securing adhesion and proper seating for the denture, is made when the material is (A) confined and (B) heated so that the surface is decidedly plastic, but in which the temperature of the material, and in consequence its plasticity, gradually diminishes until the tray is reached, at which place there is the least plasticity.

While an impression is being taken under these conditions, the underlying semiplastic compound will take on the general form of the parts to be secured in the impression, while the surface of the

impression, being the most plastic, is driven into every detail.

The most striking example of accuracy in a modeling compound impression is that type of impression of a tooth prepared for a jacket crown. In this case the metal band is filled with compound and pressed home and thus the impression material is confined, and the more plastic portion is forced up against the prepared tooth by the less plastic material on the exterior.

Now, returning to the use of compound in denture work (which is a much different problem from that involved in securing an impression of one prepared tooth, on account of the larger areas of tissues of varying densities), it will be found that each time the modeling compound is reheated and dipped into water at 150°F. and returned to the mouth, the harder parts of the mouth drive the plastic surface of the material toward the softer parts of the mouth, until the pressure, equivalent to a light biting stress, is equalized and the impression is satisfactorily seated.

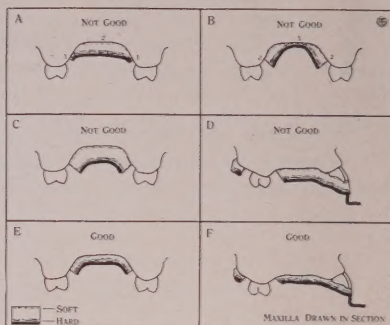
With an accurate special tray and with a comparatively small and uniform depth of impression compound, it is proposed that the foregoing processes (A and B) are facilitated as below:

(A) *The confined impression material.* While it is not possible or desirable to confine the material in the sense that it is confined, for example, in the process of taking an impression in a metal band for a jacket crown, in which lateral extrusion of the material is prevented by a metal band, yet it is proposed that the close proximity of the tray to the tissues to be taken, with the correspondingly close proximity of the plastic surface of impression material to the less and less plastic subjacent layers, will retard extrusion of the material out over the periphery of the tray to an extent which appears in practice to be sufficient for practical purposes.

(B) *The plastic surface is pressed home by the subjacent less plastic impression compound.* (1) This action is more positive because in a small depth of material the less plastic material adjacent to

the tray is closer to the plastic surface next the parts to be taken in the impression, and is therefore more positive in its

FIG. 17



Another reason why the modeling compound impression should be kept of uniform and small thickness. A and B, a transverse section taken between the molars of D and F, shows that when these impressions are taken with comparatively inaccurate trays, there is a tendency toward a comparative lack of uniformity in the density of the subjacent modeling compound. At 1-1-1 an excess pressure is likely because the hard material next to the tray is in direct contact with the tissues; on the other hand, at 2-2-2 there is a tendency toward a comparative lack of pressure, due to the greater thickness and consequent greater plasticity of the material.

C and D. Due to the thickness of the modeling compound, even though uniform, there is a danger that much of the force between the more rigid material toward the tray and the more plastic material toward the tissues may be absorbed by the extrusion laterally of the intervening material.

E and F. With a uniform and comparatively small thickness of material, the hard part of the compound next the tray exercises a uniform and definite pressure, and also reduces to a minimum any tendency to lateral extrusion. In addition to this it may be seen that from the same cause "creeping" or other distortion of the compound is also reduced to a minimum.

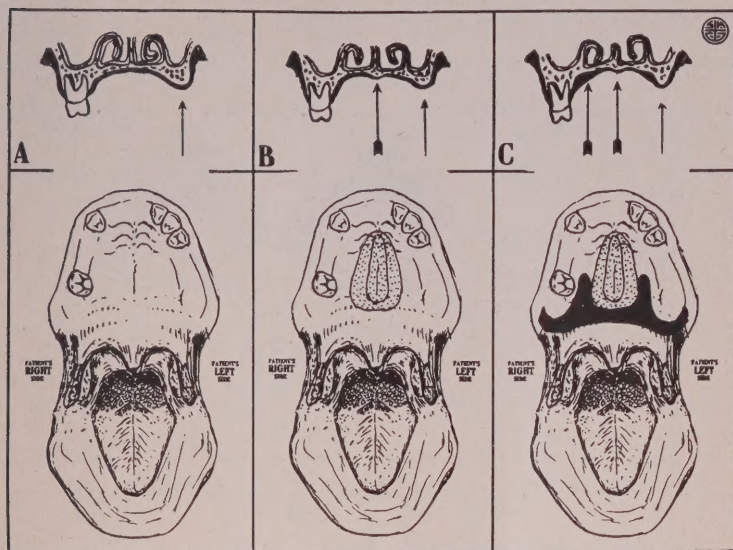
Note. Only two degrees of plasticity of the modeling compound are here shown in the drawing, namely, hard and soft. The reader is asked to picture mentally the varying degrees of plasticity in the intervening material in each case.

effect in pressing it into the finer details. (2) The action is more uniform with a uniform thickness of material, as indicated in Fig. 17.

In addition to the foregoing advantages, there is decidedly less chance of creeping or other distortion of the im-

tures which are common with full denture impressions. Here follow four of the more important of these:

FIG. 18



The three main degrees of resiliency* in the upper mouth, and the different formations of bone and mucosa giving rise to these:

(a) A section above and a plan below, of a mouth of uniform resiliency. The section, in the region of the first molars, shows the reason for this uniformity, namely, easy contours of the bone and an even thickness of mucosa. (Note the mucosa is shown black.)

(b) A section and a plan of a mouth with two degrees of resiliency, namely, a central harder area, and the remainder as in A. The section shows the mucosa thin and tense over the intermaxillary suture, while the plan shows an average outline for this area.

(c) A section and a plan of a mouth with three degrees of resiliency, namely, a softer area on either side and to the posterior of the central hard area and the remainder as in A. The section shows the cause of the softer area, namely, a greater thickness of mucosa over the base of the alveolar process.

pression compound during manipulation if a uniform layer of impression compound is firmly fixed to the impression tray by the process as indicated in Fig. 21, with its accompanying text.

22. OTHER ESSENTIALS IN THE PRIMARY IMPRESSION

The primary impression for mucosa-supported partial dentures has other fea-

(A) An accurate print of the fine detail of the structures concerned. It is quite obvious that this is essential, especially when adhesion is desired as a retaining force in partial dentures, as adhesion depends both upon the area and accuracy of the adaptation of a base to the mucosa.

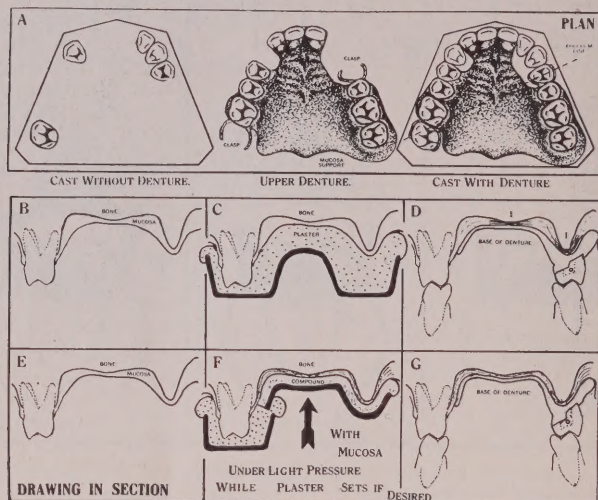
(B) The greatest area possible within the limits set by the peripheral muscles

* In addition to these three degrees of resiliency here described, other degrees of resiliency are found in the peripheral tissues. These are cared for during the process of muscle-trimming and post-damming.

and tissues. Even should the design of the partial denture (completed before the impression is considered) not include the entire area available for mucosa support, yet it is obviously a wise precaution to include it all in the impression, so that, should it develop that a greater area of

(D) An equalized pressure on the hard and soft areas. This feature is, in a sense, the most important of all, as it determines the conditions under which the denture will seat itself under the load of mastication, a consideration of which follows.

FIG. 19



The effect of plaster of Paris and of modeling compound for placing the less resilient mucosa under compression, corresponding to that of light biting stress during the impression:

(A) The plan of a mucosa-bearing restoration covering a considerable area, for reasons such as active masticatory muscles, and a mucosa of a degree of resiliency less than the average.

(B) A section of the mouth.

(C) A plaster impression, which gives the less resilient mucosa little or no compression.

(D) A denture made from this impression, which rides on the less resilient tissue and receives little or no support from the more resilient tissue.

(E) Modeling compound primary impression, held under light biting stress while the plaster of the secondary impression sets, giving a partial denture (G) which receives a degree of support from the compression and consequent rebound of the more resilient mucosa, without an undue degree of compression of the less resilient areas; in other words, an equalization of the support received from these tissues of varying resiliency.

mucosa support be desirable, this area would be available. This is especially true should adhesion be used in the region of the partial denture.

(c) A periphery shaped by muscle-trim and post-dam. This is essential in a partial denture in which adhesion is required as a retaining force.

23. DIFFERENCES IN RESILIENCY OF THE TISSUES OF THE MOUTH UNDER MUCOSA-SUPPORTED PARTIAL DENTURES; THEIR DETECTION AND TREATMENT

For practical purposes it may be proposed that there are three well-defined degrees of resiliency in the vault portion

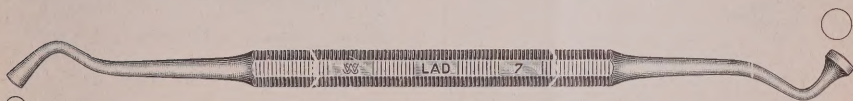
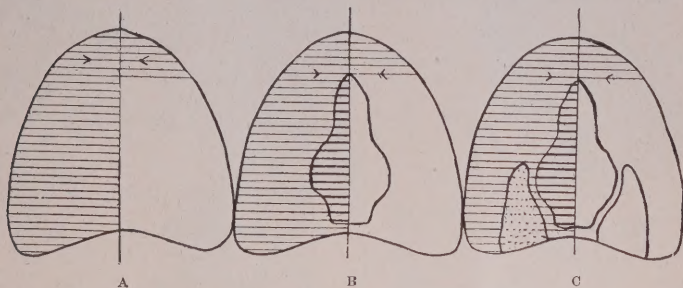
of the upper mouth, and also in the edentulous spaces in the lower mouth but much less well defined. The first is the mouth of uniform resiliency in which an examination reveals this condition due, as noted in Fig. 18, space A, to a uniform thickness of mucosa, whether this be more or less dense. The second is that of a central area, of varying forms in different mouths, which is less resilient than the remainder of the mouth, and which is caused, as may be noted in Fig.

24. PLASTER AND MODELING COMPOUND AS IMPRESSION MATERIALS FOR MOUTHS HAVING DIFFERENT DEGREES OF RESILIENCY

From Fig. 19, it may be noted that plaster used as an impression material in the ordinary way does not equalize the compression of the mucosa in its different degrees of resiliency as will modeling compound.

From observations thus far and from experience in the full denture field, the

FIG. 20



Examination of mouth for hard and soft areas: A round-headed instrument, such as the Ladmore Plastic Filling Instrument No. 7, as illustrated, is held lightly in the hand and drawn across the vault as indicated by cross lines, one side at a time, from ridge to median line. In vault A, no difference of resiliency is encountered; in vault B, the instrument climbs up a hard central area outlined in the center; in Vault C, hard area in center and soft area on either side are likewise detected. With a pencil the outline is sketched on the cast as taken from the patient. In cases where the difference of resiliency is decidedly marked, these areas may be subsequently relieved by thin metal on the cast for the hard area and carding wax on the impression for the soft areas, or by other means if preferable. On the other hand, bars or the like, crossing hard areas, may be cast, formed or bent to accommodate the difference in resiliency.

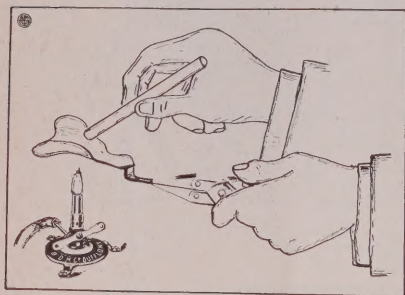
18, space B, by the mucosa being thin and tense over the central intermaxillary suture, while the third is that of three degrees of resiliency, namely, the central harder area, with a softer area usually posterior to and on either side of the central hard area, as in space C. It will be noted that the divisions above are proposed for practical purposes in choosing the impression material, and further, in relief or compensation on the partial denture if necessary.

writer has been led to hope that the practice of equalizing the compression of the mucosa by the use of modeling compound as an impression material, taking the primary impression under light biting stress and also the practice of holding the primary impression against the mucosa, also at a light biting stress, as indicated, Fig. 19, space F, will not only use the less resilient parts of the mucosa to the utmost extent in supporting loads of mastication, but will also avoid to a con-

siderable extent the frequent rebasing so often necessary after the first insertion of a partial denture, as well as maintain in a healthier condition these tissues including the subjacent bone by a more equal distribution of the intermittent load of mastication.

It must be noted that bars or other structural parts crossing the vault often must be formed to stand away from the central hard area, in addition to the equalization afforded by the impression under pressure, so that both during function and after the "settling" of the denture there will be no interference. This

FIG. 21



Applying a thin but tenacious film of compound to the tray, so as to prevent detachment of the impression from the tray during the process of taking the impression, as described in the text. See also Fig. 25, A.

is necessary in direct proportion to the amount of difference in resiliency to be found in the mouth, and only in mucosa and combination supported partial dentures.

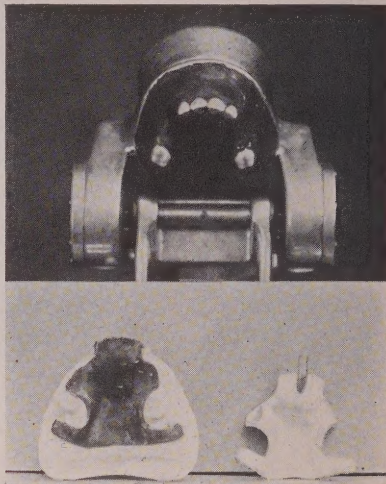
In the lower mouth the differences in resiliency in the mucosa are considerably less marked than in the upper, and may usually be cared for by the modeling compound impression under pressure.

25. LOCATING THE DIFFERENCES IN RESILIENCY OF THE MUCOSA (BY THE DENTIST)

A visual examination tells little or nothing, and a digital examination, while indicating in a general way the location of these areas, is not sufficiently accurate for practical purposes.

In Fig. 20 a method is described which will indicate accurately on the cast the location of these areas, for the purpose of relieving or otherwise compensating partial or full dentures when the difference in the degree of resiliency in the

FIG. 22



Patient, study cast, and tray. For convenience in illustration, the mouth will be represented in modeling compound with porcelain biscuited technique teeth on a Hanau manikin.

The Hanau manikin, which is a working model of the jaws designed by Mr. Rudolph Hanau for demonstration purposes and for the use of students both in taking impressions and constructing artificial dentures, is used as above in preference to an actual patient, because it is possible to obtain the variety of cases and clear pictures of the various stages of the impression which would be impossible to obtain in the mouth.

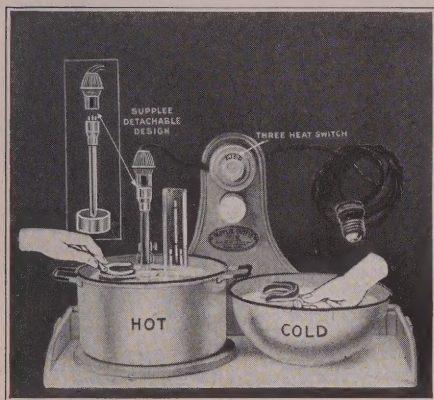
mouth indicates the use of this precaution. If necessary, the foramina, as, for example, the anterior and posterior palatine, may be similarly relieved.

26. THE PRIMARY UPPER IMPRESSION IN MODELING COMPOUND (BY THE DENTIST)

For the reasons just stated, the equalization of the support from tissues of varying resiliency, the errors in modeling

compound technique are practically eliminated by the accuracy of the tray. A primary impression of modeling compound is recommended by the writer.

FIG. 23

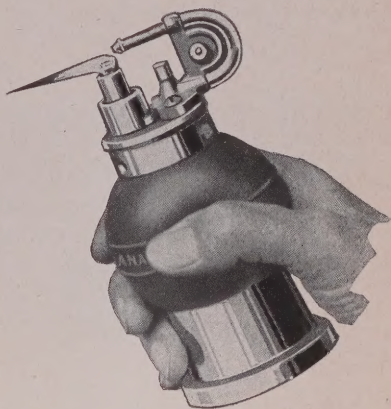


The Supplee outfit for working modeling compound.

The tray, having been finished, the dentist, should he desire it, may at this stage try the tray in the mouth. After this has been done and any changes desired are made, a film of modeling compound should be applied. This is done by first grasping the handle of the tray

with a suitable pair of pliers and holding its lingual side at a safe distance over the flame (having in mind that commercial tin melts at 442°F.) and at the

FIG. 23A

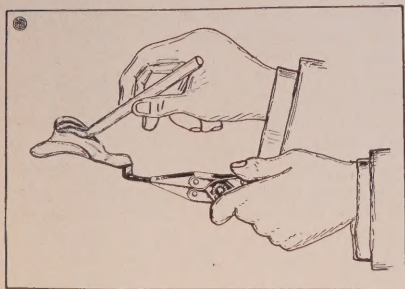


The Hanau Alcohol Torch

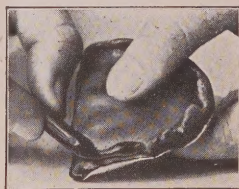
An example of a useful appliance for applying heat to a modeling compound surface.

same time holding upon the floor of the tray a stick of modeling compound as in Fig. 21. As soon as the compound begins to melt, withdraw the tray from the flame and then continue to cover the whole floor of the tray with a film of modeling compound from the heat contained in the

FIG. 24



A



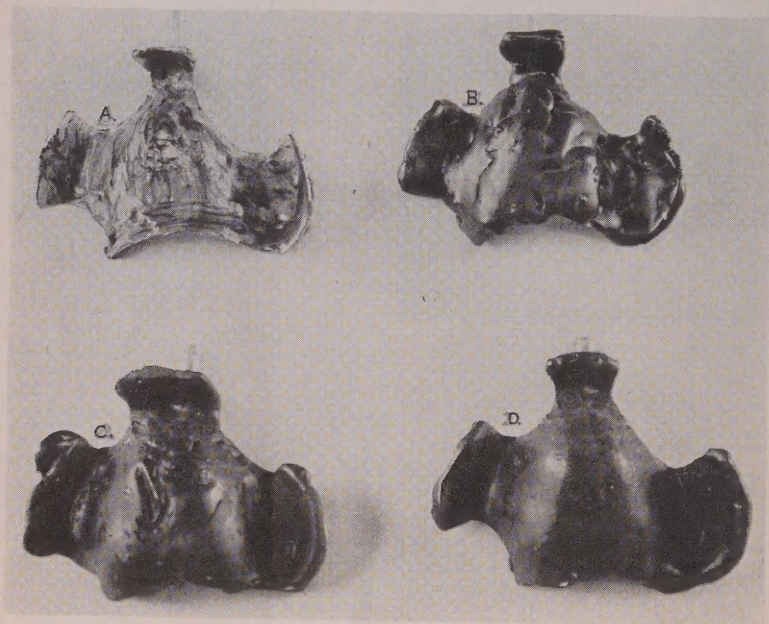
B

"Tracing On" Modeling Compound: The compound in stick form is heated over the flame and is then traced on. (A), Tracing compound on the floor of the tray with the result as in Fig. 25. B. (B), tracing modeling compound on the periphery of impression. (Illustration supplied by Detroit Dental Mfg. Co.)

tray. Fusing as it does from the heat within the tray, this film is exceedingly tenacious, and when further compound is added to it, reduces to a minimum the danger of detachment of the impression from the tray during the subsequent stages in taking the impression.

oroughly and uniformly softened with the Hanau blowpipe, as shown in Fig. 23, B, then dipped quickly into water at 150°F., so as not to burn the patient, passed into the mouth and firmly seated, and held in position and cooled, preferably, with ice-water until properly hardened. Should

FIG. 25



Seating the primary impression: A, thin film of compound; B, compound traced on; C, first impression with deficiencies; D, finished primary impression.

27. THE PRIMARY UPPER IMPRESSION; SEATING THE IMPRESSION (BY THE DENTIST)

Have at hand means for keeping water at 150°F., a Hanau blowpipe, or other accessories as in Fig. 23 and 23, A, preferred by the dentist in one or other of the scientific modeling compound impression techniques.

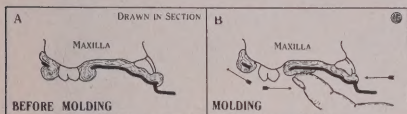
Have, as already described in Fig. 24. A, the impression tray covered with warm compound traced on about 1/8 inch thick. This traced-on compound is thor-

there be an excess of compound sufficient to extrude into the perforation of the tray and around the undercuts, as in Fig. 26, space A, this compound should be quickly and gently molded back over the tray with the tip of the index finger, before the material cools, as shown in Fig. 26, space B. Upon removal, deficiencies in the impression, as in Fig. 25, C, will likely be found here and there, and to correct these deficiencies, modeling compound in stick form is traced on. The whole is again uniformly heated and softened, dipped into water at 150°F..

returned to the mouth, and thoroughly chilled with ice-cold water.

This process is repeated if necessary until the impression, without deficiencies, is complete and the vault and ridge portion are seated to the satisfaction of

FIG. 26



Molding the compound away from the undercuts. Should there happen to be a slight excess of compound, it may be extruded into the space of the perforation, and around the undercuts; and should the impression be permitted to harden in this form, as seen in A, it would either lock in place, or would become either distorted or fractured during removal.

Should this extrusion occur, it is suggested that the index finger be applied, stroking the excess material, as at B, back on the lingual side of the tray. Later this compound is removed by cutting at the time when the impression is flared at the perforations. If necessary, the compound may also be molded back against the teeth, as, for example, about the anteriors.

the dentist. The impression is then trimmed and flared about the perforations, as in Fig. 25, D.

In partial denture cases, approaching in form that of full dentures, where an adequate degree of adhesion is required, the technique of seating and the subsequent steps of muscle-trimming and post-damming may well be subdivided into individual and successive steps, as advocated by any of the well-known authorities on modeling compound technique, including that correctable method in which the impression is first seated on the study cast and then corrected in the mouth.*

The primary impression should be finished to pass all tests required. Figure 24, B, illustrates the application of

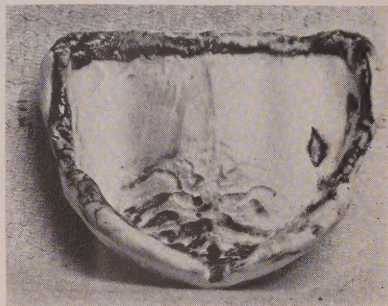
modeling compound to the rim for muscle-trimming.

This technique having been accomplished, the compound of that part of the impression adjacent to the remaining teeth is trimmed and flared to permit easy removal of this secondary impression. (See Fig. 2, space 5.)

28. VARIATIONS IN MATERIALS FROM ABOVE FOR PRIMARY UPPER AND LOWER IMPRESSIONS

Should the dentist desire, the compound primary impression may be completed by applying thin plaster and returning to the mouth, thus giving the impression a thin plaster lining. Plaster alone also may be used if desired, especially in hard bony mouths. Another method has been advocated for full den-

FIG. 27

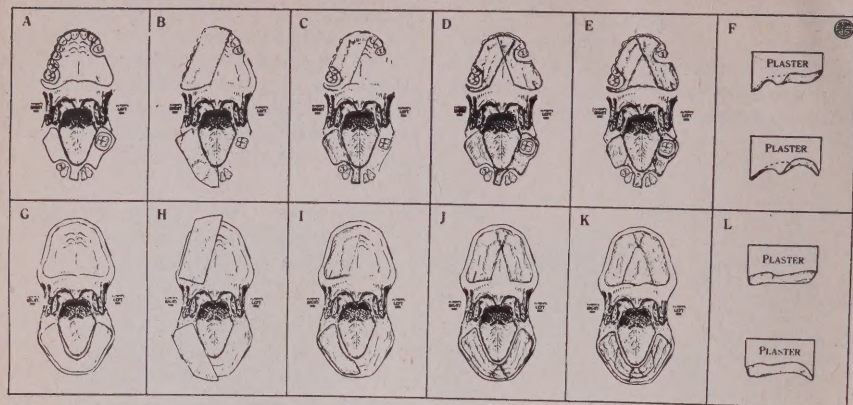


A plaster impression with a periphery of modeling compound used in a full denture. (After Rupert Hall.) In this method care must be taken to use a *light pressure* in seating the impression, in order to avoid overcompression of the border tissues.

ture service, namely, a modeling compound rim traced around the entire periphery of the impression tray, muscle-trimmed and post-dammed if necessary, and then used to contain plaster, as shown in Fig. 27. Care must be taken to use a light pressure in seating the impression in order to avoid overcompression of the border tissues, and consequent atrophy of the parts.

* A fine description of the latter appears in the *Dental Items of Interest* for 1924, at p. 866, from the pen of Dr. Alfred Nelson, Detroit.

FIG. 28



Making a wax pattern for a special cast tray direct from the mouth, as described in the text.

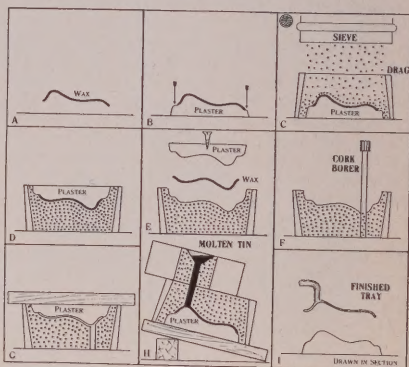
29. MAKING A SPECIAL TRAY DIRECT FROM THE MOUTH, FOR PARTIAL OR FULL DENTURE IMPRESSIONS, UPPER OR LOWER (BY THE DENTIST AND ASSISTANT)

It is quite possible to construct patterns for cast trays direct from the mouth without a study cast for either partial or full denture impressions, yet it is not recommended as a routine practice; also, it may be advantageous for cases in surgical prosthesis or in cleft-palate impressions.

Figure 28, A to F inclusive, shows this process applied to trays for primary-secondary partial impressions; and G to L inclusive, the same process applied to the making of trays for full impressions.

In A will be seen the outline of the proposed tray, and in B, a strip of wax applied to the mouth the same as would be applied to the study cast in building up the wax pattern. (See Fig. 6.) Molding the wax in the mouth with fingers will reveal the prints of the teeth. The wax is then removed, trimmed, and further molded in the mouth, as in C. This is surprisingly easy, because of the temperature within the mouth. A second piece is then formed on the other side of the mouth in the same way, always slitting and folding the wax over any prominences, such as the tuberosity, to avoid stretching the wax; the two pieces

FIG. 28A



Making casting direct against the plaster cast, which then becomes a core.

The details of a shorter method are shown here. This method is used for casting trays formed directly in the mouth, as in Fig. 28, in which the plaster casts in F and L, with their wax patterns, become as in space B in this drawing.

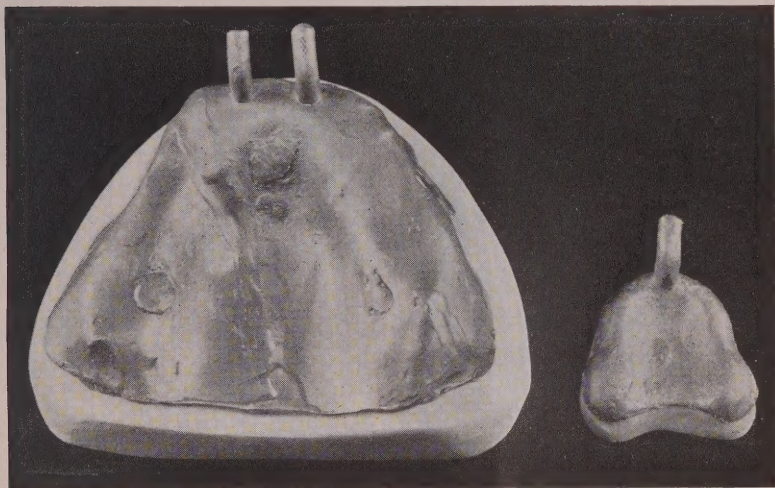
C, Sifting in the Calcar, after a light coating of French chalk has been applied; D, drag of flask as seen in C, filled and inverted; E, plaster cast and wax pattern removed from the mold; F, making the handle, which is also the sprue of the casting; G, plaster cast, which now becomes the core, is returned to the mold, leaving a space corresponding to the wax pattern and sprue (note that the plaster cast must be thoroughly dried); a piece of wood is laid on top for convenience in inverting and pouring; H, the shaft collar (used as a weight) is filled with Calcar and pierced by the smallest cork-borer, as in F; I, finished tray.

of wax are then brought together in the mouth, as in D, and the finger applied to the line where they join, to give a print of each which permits a sufficiently

accurate reassembly outside of the mouth by a hot wax spatula.

This joined wax pattern is then returned to the mouth, and a triangular

FIG. 29

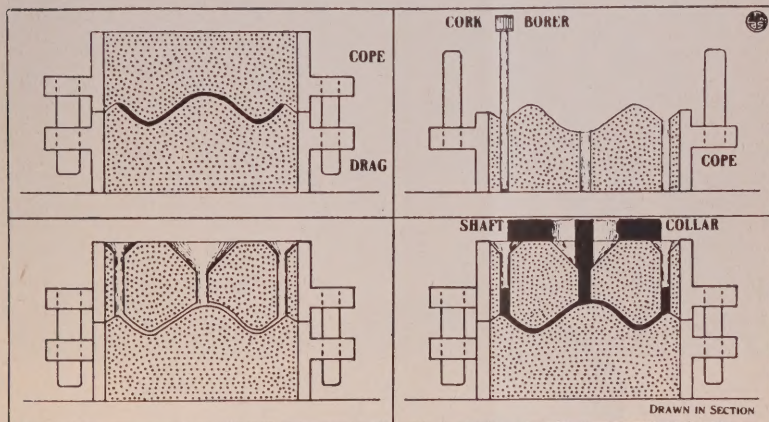


A contrast in impression trays: Two impression trays, unusually large (measuring 4 inches across) and unusually small (measuring $1\frac{1}{2}$ inches across), both from cases in practice.

A

FIG. 30

B



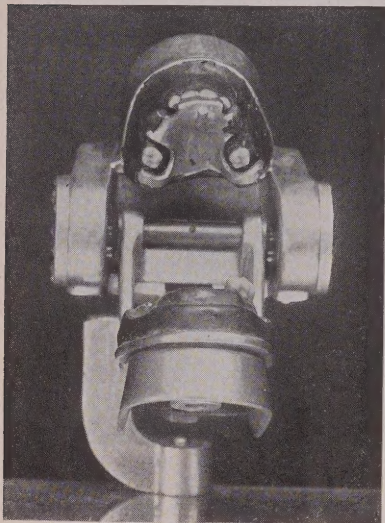
C

D

The use of "risers" or air vents in large tray castings. These are made with a cork-borer as illustrated in space B, so that the trapped air may readily escape, as in space D. The metal will rise in these, as noted in space D, and must be cut off in the casting.

piece (note the difference in the shape between the upper and lower) is overlaid on the previous two joined pieces, pressed home, removed from the mouth and with a hot spatula firmly fastened to the first two. A plaster base for molding, as in

FIG. 31



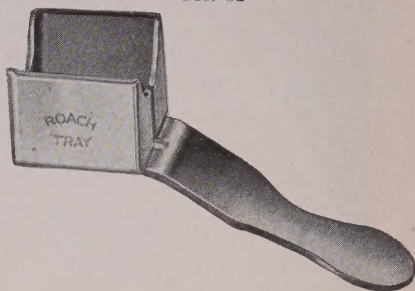
The appearance of a completed primary impression in the mouth. (As in Fig. 22, the mouth is represented in modeling compound with porcelain biscuited technic teeth on a Hanau manikin.)

Fig. 28, F and L, is obtained by pouring plaster into the wax pattern. If the contours of the pattern are not abrupt, the wax serves as a pattern, but if they are so abrupt as to require a "lift," then a second layer of wax is added, which be-

comes the tray, and the pattern formed in the mouth becomes the "lift." (See Figs. 5 and 6.) A convenient means for making the subsequent tray is shown, Fig. 28, A.

For making trays for full denture impressions the process is identical but simpler because of the absence of teeth. (See Fig. 28, G to L.) It is ideal for

FIG. 32



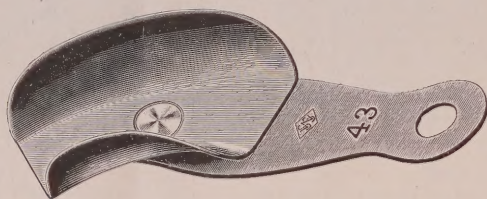
The Roach tray for taking impressions of an individual tooth or a small group of teeth.

the occasional case in which the edentulous mouth is too small or too large to accommodate a stock tray, as in Fig. 29. For exceptionally large trays "risers" should be used as in Fig. 30.

30. THE SECONDARY UPPER IMPRESSION (BY THE DENTIST AND ASSISTANT)

We now have, with the primary impression in place in the patient's mouth (Fig. 31), an impression which, like a scientifically made modeling compound impression for a full upper denture, compresses the resilient tissues in proportion to their resiliency under light

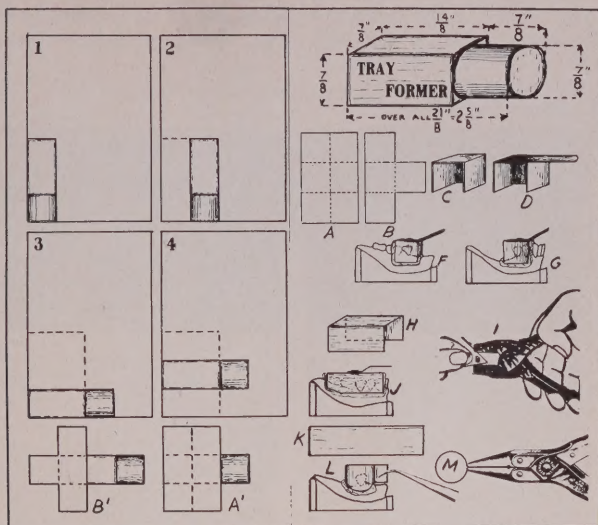
FIG. 33



Bridge impression tray, S. S. W. No. 43, for larger groups of teeth.

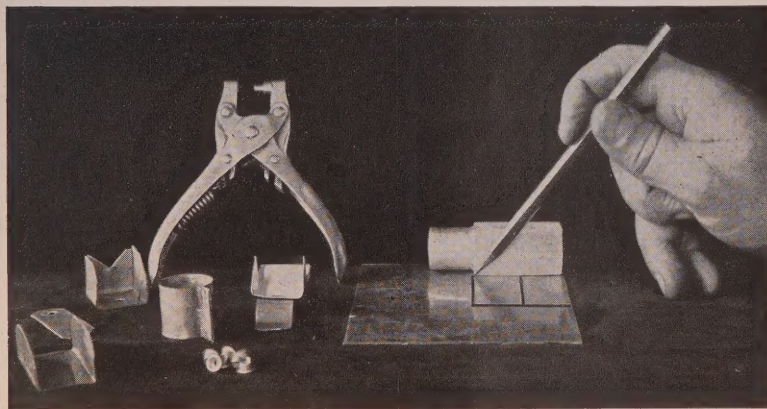
biting stress, or for that matter any stress as provided for by the dentist in process still uncovered. The method suggested is the (primary impression being

FIG. 34



The tray former and other material used in making soft-metal trays by the technique described in the text.

FIG. 35



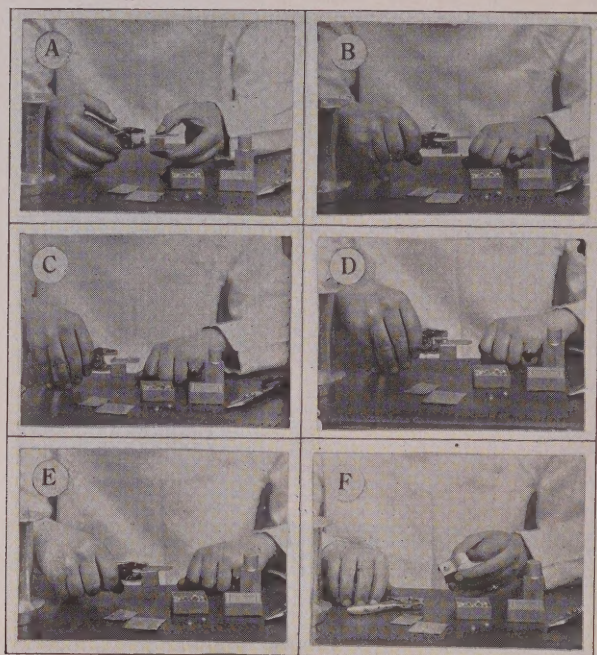
Laying out the soft-metal tray on air-chamber metal with the tray former, as described in space 3, Fig. 34. A solid head eyelet punch, some eyelets, and some finished and partly finished soft-metal trays are also seen.

his compound technique, but with the undercuts about the teeth and alveolar stress) to take these undercuts with sec-

ondary impressions with plaster, using individual stock trays, or with specially constructed soft-metal trays. (See description of soft-metal trays, Figs. 34, 35, 35, A.) The plaster of the secondary impression is carried over a sufficient

at present on the market, bearing the names of their designers, Roach, Smedley, Kidder and others. For average conditions these are entirely suitable, but the presence of the primary impression in the mouth often calls for a tray some-

FIG. 35A



Eyeletting the handle on the tray. This convenient method of attaching a handle to a soft-metal tray, as shown in Figs. 34 and 35, is here illustrated in detail: A, Finished tray and handle held in position in left hand and with the punch part of the Solid-Hed eyelet punch kept below; B, a hole is punched; C, the punch is then opened, and eyelet selected; D, eyelet is placed in position over the punch; E, punch is closed; F, with the result that the handle is eyeletted to the tray; during the closure of the punch at E. Do not press so hard that the handle will be so tight that it will not rotate readily.

area of the primary impression so that it may be accurately reassembled after removal from the mouth.

what out of the ordinary. It is here that a soft-metal tray, as constructed in Figs. 34, 35 and 35, A, answers admirably.

31. THE SECONDARY UPPER IMPRESSION, STOCK TRAYS

A number of stock trays suitable for taking impressions of single teeth or groups of teeth up to three or four are

32. THE SECONDARY UPPER IMPRESSION, SOFT-METAL TRAYS (BY THE ASSISTANT)

Soft-metal trays for individual plaster impressions may be readily made on a

simple tray former of wood or metal. This tray former may be easily made by a machinist from a rectangular block of wood or metal $7/8$ inch x $7/8$ inch x $2\ 5/8$ inches, by placing it in the lathe and turning a cylinder in length $7/8$ inch, or one-third the entire length of the tray former; or by taking a rectangular block of wood $7/8$ inch x $7/8$ inch x $1\ 3/4$ inches, and nailing to the end of it a wooden cylinder $7/8$ inch by $7/8$ inch.

Three forms of trays are constructed of air-chamber metal 19 gage (B. & S.), rolled to 21 and are made as follows:

(A) *Trays for impressions of teeth at the end of a series.* As, for example, with space mesial to teeth (Fig. 34, F) and with space distal to teeth (Fig. 34, G). In Fig. 34, an area twice the width and the same length as the tray former is laid off with a pencil on a sheet of air-chamber metal (1 and 2). This area is readily divided into thirds (3 and 4), because the tray former is one-third as wide as it is long. This layout, when cut from air-chamber metal, gives a figure as in A. Cut off the two corner squares, giving a T-shaped piece as in B, making when pressed over the former by the finger, as in B', an open-box-shaped tray as in C. Cut handle from air-chamber metal and attach as in D, with solid head eyelet punch as in I also as in Fig. 35, A. The eyelet attachment will allow the tray to swing, as in F and G.

(B) *Trays for impressions of a tooth or teeth in the center of a series of teeth.* In the same manner, lay off a shape, as in Fig. 34, space A. Then lay it over the tray former as in A'; bend it into form as in H. Attach handle and proceed as in I, also as in Fig. 35, A.

(C) *Trays for impressions of isolated teeth, as in L.* Cut a strip of air-chamber metal as long as the combined width and length of the tray former and also make it as wide as the width of the tray former as in K ($7/8$ inch x $3\ 1/2$ inches). Pinch this over the cylindrical end of the tray former, as in M. Complete the tray by closing one end with plasticine rolled thin.

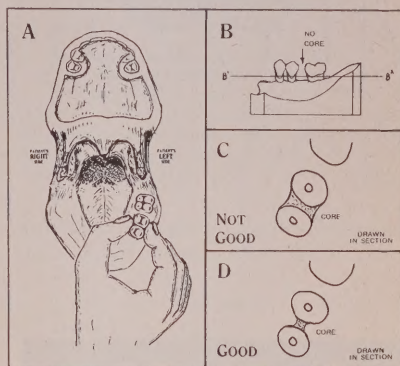
These soft-metal trays may be trimmed

with a small pair of shears to follow the contours of the parts adjacent to the flanges or floor of the primary impression tray.

33. THE SECONDARY IMPRESSION: TAKING THE IMPRESSION, USING PLASTER WITH SOFT-METAL TRAYS, ALSO THE USE OF CORES, PLASTICINE AND COMPOUND (BY THE DENTIST AND ASSISTANT)

As the secondary impressions are taken with the primary impression in place in the mouth, the first step is to cut off the handle of the primary tray if it will be

FIG. 36



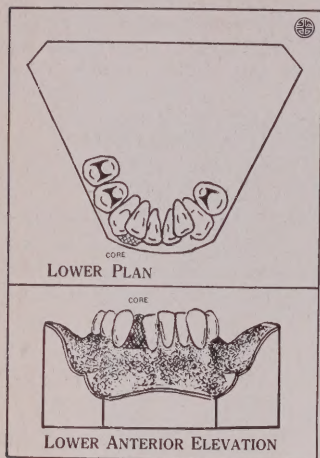
Plasticine cores (these are applied when the teeth are in contact): A, Position of hand in applying core; B, no core indicated when contacts are lost; C, cross-section of unfinished core for space as at B'-B', between the bicuspid; D, completed core, showing unfinished core as at C, trimmed small with an excavator or plastic instrument.

in the way of the secondary impression or impressions. This may be done with the side-cutting pliers.

Should there be large triangular spaces between the remaining teeth, the plaster used in the secondary impression may break off so as to mar the impression. This difficulty may be overcome by a thin core of plasticine pressed by the thumb and finger into the triangular space, as

in Fig. 36, A. This may leave the core too thick, as in Fig. 36, C. If so, it is

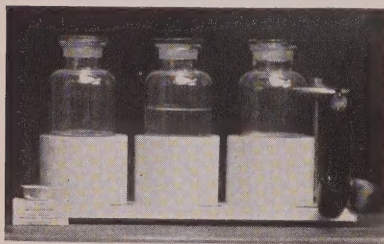
FIG. 37



Compound cores: These are pressed into place and molded to an approximate rectangular shape, so that on removal they will fit into prints made in the plaster or compound.

then trimmed with a plastic instrument or excavator, as in Fig. 36, D. As a rule

FIG. 38



Control solutions for plaster: This stand contains solutions which accelerate the plaster to a $2\frac{1}{2}$, 5 and 10 minutes' initial* set.

plasticine cores are necessary only when the teeth are in contact. When the teeth

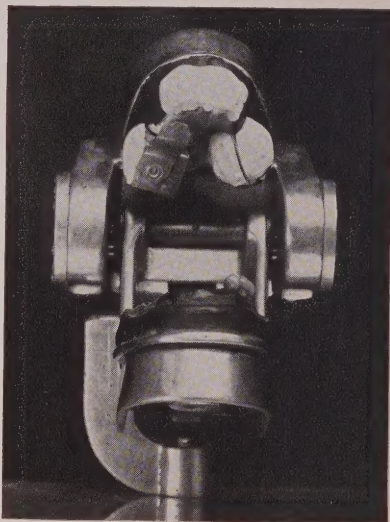
* At the time of the initial set, crystallization has begun and all manipulation should cease.

are separated to any degree, as may be noted in Fig. 36, B, the plaster will as a rule come away clear. With larger spaces of such a shape as would cause the plaster of the primary impression to break off so as to mar the impression, compound cores may be made, trimmed to a semi-rectangular form as in Fig. 37.

Plasticine cores are indicated where an accurate reproduction of the small contours involved is not required. Compound cores are indicated where an accurate reproduction of the contours is required.

After providing for the cores (if necessary), the next step is that of verifying the firm fixation of the primary impres-

FIG. 39

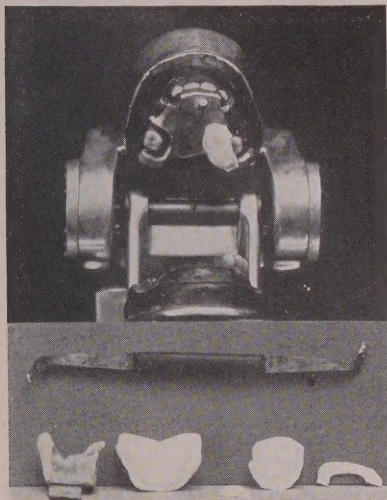


Primary and secondary impression in place: Mouth as in Figs. 22 and 31.

sion. Because of the accuracy of this impression, especially in uppers, ample adhesion is usually present. Should the required adhesion be lacking because of limited area of the primary impression or because of any other uncontrollable cause, fixation should be assured by the use of a minimum quantity of any one of the various adhesive powders.

The primary impression being securely in place in the mouth and the secondary

FIG. 40



Secondary impression (Fig. 39) partly removed but not assembled.

The anterior secondary impression has been removed by inserting the index finger high up on the impression under the lip, and pressing it downward and forward. In this case it has come away in two pieces.

The right secondary impression (taken in a soft-metal tray) has been removed by first disengaging the tray, then dividing the impression and prying it apart with a Gritman plaster knife No. 7,* reassembling it in the soft-metal tray.

The left secondary impression has been removed, first by lifting out the vane made of soft metal, about 22 gage, fastened to the tray of the primary impression with plasticine before the secondary impression is taken, for the purpose of dividing the secondary impression along a predetermined plane of cleavage, as described in detail in Fig. 49c.

trays being in readiness, a pledget of cotton is moistened with cocoanut or olive

* Unfortunately the Gritman plaster knife No. 7, as illustrated in Fig. 40, which has been designed for and is ideal for this purpose, has been taken off the market. The only instrument that the writer has been able to find which even approaches it, is the Ladmore plastic instrument, No. 5, as shown in Fig. 41.

oil or other desirable separating medium, and applied to the remaining teeth and to those adjacent parts to be included in the secondary impression.

A plaster,† the set of which may be readily regulated, preferably by the use of control solutions of water with a suitable percentage of accelerator, is preferred by the writer. The control solutions are used instead of water to hydrate the plaster. Solutions for 2 1/2, 5 and 10 minutes' set may be kept for use in glass containers, as in Fig. 38.

34. THE SECONDARY IMPRESSION: TO SECURE THE SECONDARY IMPRESSION OF THE REMAINING TEETH WITHOUT ALTERING THE DEGREE OF COMPRESSION OF THE MUCOSA PRODUCED BY TAKING THE PRIMARY IMPRESSION (BY THE DENTIST AND ASSISTANT)

The advisability of holding the primary impression against the tissues at a light biting stress has been proposed, Figs. 18 and 19 with the accompanying text. It is proposed as desirable that the pressure exerted during the taking of the secondary impression should not alter the degree of compression produced in the primary impression.

If a partial denture is held against the tissues under a greater stress, an atrophy of the tissue under it will likely result. This might well happen if, in the secondary impression, too great a pressure were exerted in holding the primary impression in place. If the retainers fitted to the denture were unyielding, they would always retain the denture made from this impression in a state of over-compression against the mucosa.

On the other hand, should it be desired that a minimum of pressure be exerted on the mucosa, the adhesion between the primary impression and the mucosa will in all probability hold the impression to the tissue in the relation desired.

† As for example, Kerr's plaster used with accelerating solutions.

35. THE SECONDARY UPPER IMPRESSION. OTHER METHODS, USING PLASTER (BY THE DENTIST AND ASSISTANT)

Another method for obtaining a secondary plaster impression is that of introducing the plaster to place freehand either from the tip of a small plaster

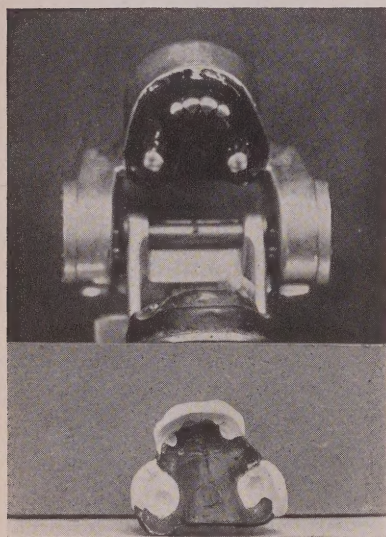
ried to place by lightly patting the upper lip; c3 represents the process of rolling out plasticine, keeping the roller and the table wet to prevent sticking. The roller is a paperhanger's seam roller and must be a cylindrical one as shown in c3 plan, not a barrel-shaped one; c4 shows on the

FIG. 41



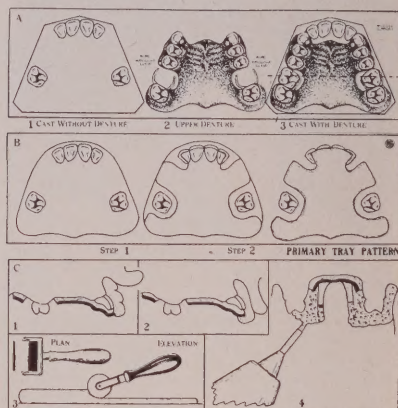
Ladmore instrument, No. 5.

FIG. 42



Impression (Figs. 39 and 40) assembled.

FIG. 43



Applying the plaster of the secondary impression freehand or with a plaster syringe: A, the design; B, the development of the tray outline; C1, plaster placed under the lip from spatula; C2, plaster worked to place by patting lip; C3 and C4, making and applying a plasticine coffer-dam for use with plaster syringe.

spatula or from a syringe designed especially for use with plaster.

Figure 43, Section A, 1, 2 and 3, represents a design of a mucosa-supported denture; B, 2, outline of the impression tray, exposing the undercuts as developed on the cast; c, plaster of the secondary impression just introduced with the upper lip raised; c2, the same plaster car-

patient's right, plaster being introduced into the coffer-dam made from the rolled plasticine by a plaster syringe (shown in part), while the right side shows the coffer-dam full of plaster. No coffer-dam is necessary on the buccal side, the cheek (or lips as the case may be) serving most effectively for that purpose. Details of a plaster syringe are shown in Figs. 44,

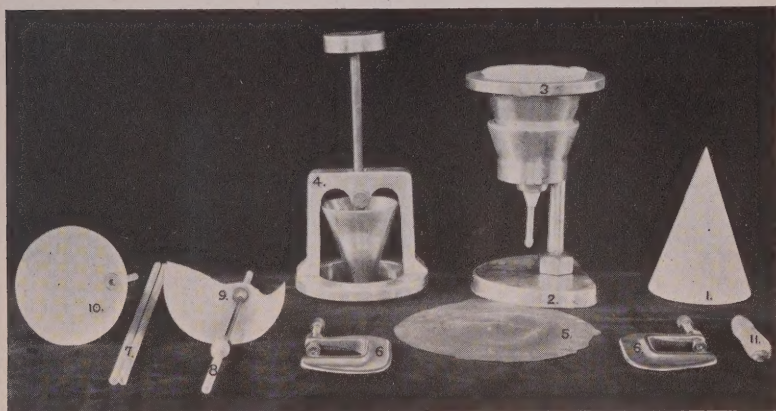
45, 46, 47 and 48, in which a four-ounce conical waxed paper cup (known in the trade as the Vortex) is perforated at its apex sufficiently to allow the insertion of a short length (about 3 inches) cut from an ordinary drinking straw. This is fastened to the inside of the cup by plasticine and placed in the body of the syringe and filled with plaster with a definite time control for setting; a thin sheet of rubber-dam is laid on and the head is

mouth without difficulty. After use, the straw and paper cup are thrown away; the dam may be used again if washed.

36. THE SECONDARY UPPER IMPRESSION. OTHER METHODS, USING MODELING COMPOUND (BY THE DENTIST AND ASSISTANT)

In many cases secondary impressions in modeling compound may be prefer-

FIG. 44



A type of plaster syringe, working drawings of which are seen in Fig. 45. The syringe is here shown ready to fill with plaster with parts as follows: 1, Waxed paper cup (the Vortex paper cup) to contain the plaster; 2, stand used to support the body while filling the syringe; 3, body of the syringe (note cup in position with drinking straw attached, the latter temporarily closed with a small ball of plasticine); 4, head of the syringe, carrying conical plunger, with a set screw; 5, circle of heavy rubber-dam* to be interposed between the head and body as a diaphragm; 6, clamps for clamping the head to the body; 7, drinking straws; 8, a two-inch length of drinking straw cut off and mounted with plasticine on one end of attaching tool; 9, other end of attaching tool to attach with plasticine straw to cup, the end of the cup having been clipped off to allow the straw to pass through; 10, showing plasticine attachment; 11, a small lump of plasticine (Harbutt's English). Certain minor changes are considered as improvements in the legend under Fig. 48.

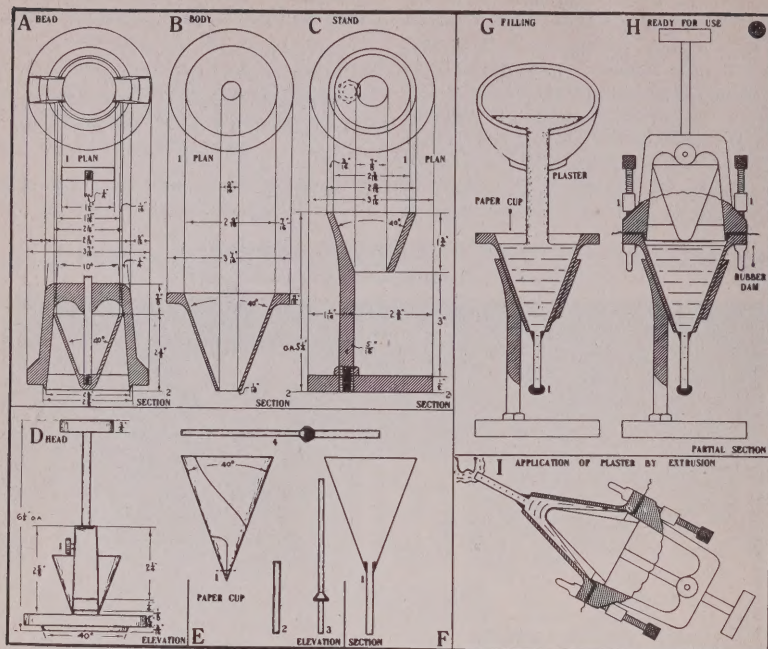
clamped on. The cover contains a conical plunger which, in pressing upon the rubber-dam diaphragm, causes the plaster to extrude through the drinking straw. A mix of the proper consistency is such as will remain on the palm of the hand, with the palm downward, without falling off. This will remain in the upper

able. This technique has frequently appeared in dental literature under the caption of sectional compound impressions, examples of which may be noted in Figs. 50, 51, 52 and 53.

Figure 51, section 1 (which shows Fig. 50 in section) shows a common case in which a direct removal will give a dis-

* The writer has used S. S. W. black, medium weight rubber-dam with satisfaction. The circle of rubber-dam may be reinforced with a circular tire patch.

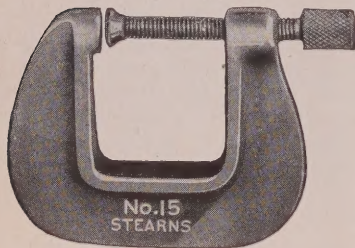
FIG. 45



Working drawings of plaster syringe: This syringe is composed of two main elements, the head, carrying a conical plunger and the body, which carries the paper cup which holds the plaster: A shows the head in plan and section with dimensions; B, the body. A stand useful while filling is shown in plan and section at C, while D shows a side elevation of the head, with set screw at 1. E shows the Vortex drinking cup with dotted line showing where the end is clipped off; E2, length of drinking straw, and E3 the small tool with which the straw is fastened to the cup. E4 shows the straw mounted on the tool ready to fasten to the cup with plasticine as in F. G shows the act of filling the syringe, using the two clamps which fasten the head to the body. H shows the syringe assembled for use with the rubber-dam diaphragm and the two clamps which fasten the head to the body. I shows the position of the plunger and diaphragm during the extrusion of the plaster.

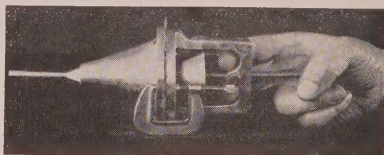
Stearn's Handy Clamp No. 15 is used for clamping the two parts of the syringe together, Fig. 45A.

FIG. 45A



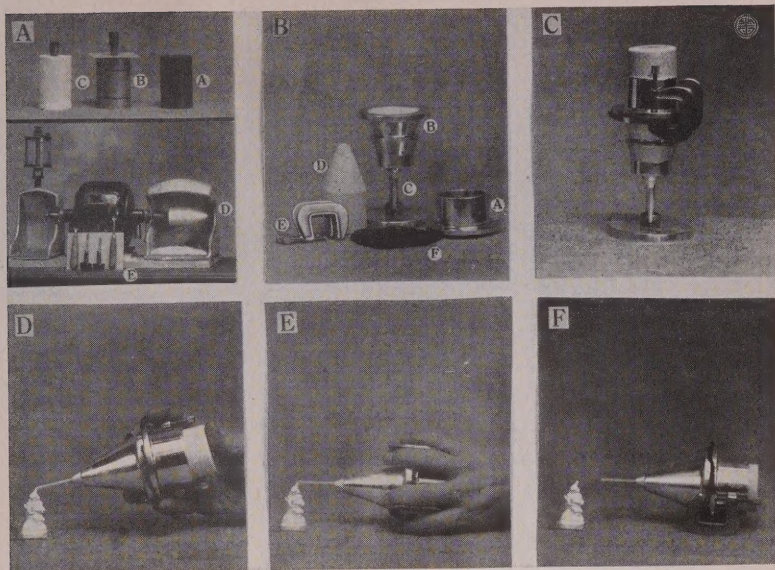
Stearn's Handy Clamp No. 15.

FIG. 46



The plaster syringe filled with plaster ready for use, showing its position when held in the hand.

FIG. 47



Another plaster syringe (student's model).*

This syringe is easier to construct, but somewhat less convenient in manipulation than the type described in Figs. 44, 45 and 46. It differs only in the head and the plunger, the former being tubular with a slight taper for convenience in molding, while the latter is detached from the head and is made of plaster, wood or other light material which may be made impervious to moisture. Detailed working drawings follow in Fig. 48.

A shows the making of the plunger out of plaster on an ordinary polishing lathe. A piece of soft metal or other material is made into a tubular form by being wrapped around some cylindrical object a little larger than the cylinder of plaster required, which is at least $2\frac{1}{4}$ inches diameter x $4\frac{1}{4}$ inches length. A disk of the same diameter as the cylindrical object is cut of cardboard or plasticine and is laid on the table; then the soft-metal tube is slipped over it, fastened with rubber bands, filled with soft plaster, and the taper chuck of the lathe, previously oiled and slipped through a perforated piece of cardboard, is laid centrally over the filled tube as in B. When the plaster sets and the soft-metal tube, cardboard, etc., are removed, a plaster cylinder as at C is the result, in which, in a central position, is the taper chuck of the lathe. The cylinder and chuck are then placed in the lathe, which is caused to revolve at slow speed until the cylinder is turned true; and with such tools as the scrapers and Pearson trimmers as at E, the cylinder is finally turned to form and sized with a Boley gage as at D, after which it is filled in stearic acid for a few moments to make it impervious to moisture. A good spatter guard† is convenient during the process of turning. With reasonably good castings, no machine work except polishing is necessary on the head and body of the syringe, and only patterns and castings are required.

B shows the syringe ready for filling: A, the head; B, the body with paper cup and drinking straw inside; C, the stand; D, the plunger; E, the clamps (Stearn's No. 15); F, the rubber-dam which is used as a diaphragm.

C shows the syringe filled ready for use.

D shows the extrusion of plaster, which is heaped up for demonstration on a glass square.

E, note the hand-grip, with fingers on each side of the clamps, which is a picture taken from behind, showing this arrangement of the fingers.

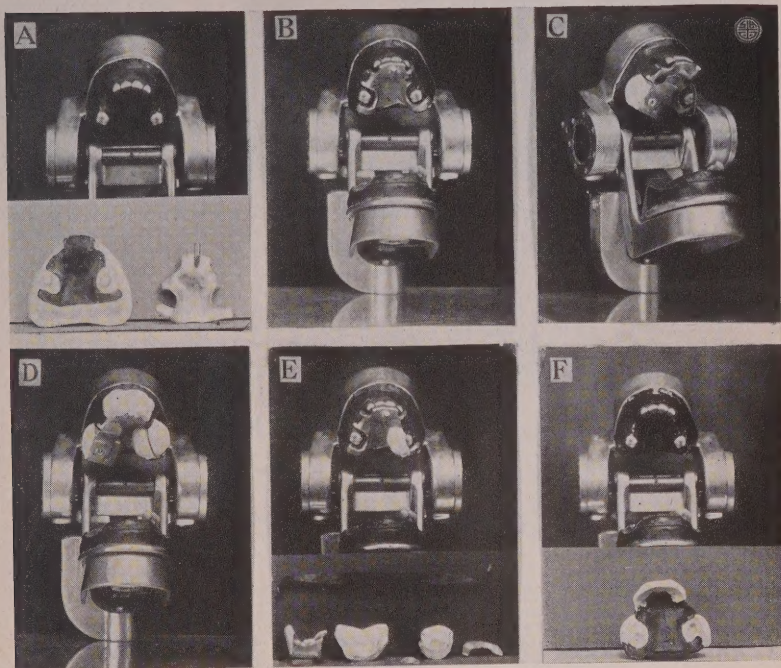
F shows a convenient position for the syringe while not in use.

* This syringe is called the student's model, because it may be adapted as a project (or exercise) in undergraduate classes in dental technology.

† The cast-iron spatter guard shown was designed by Mr. E. M. Rigsby, Faculty of Dentistry, University of Toronto.

modeling compound as an impression both sides of a mouth, especially in the material must either be parallel to, or upper mouth, is very frequently the cause

FIG. 49



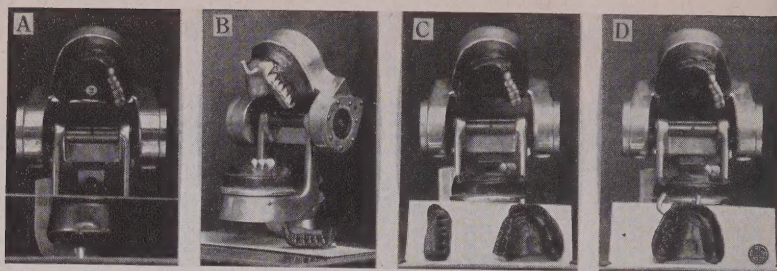
The plaster syringe and its uses in taking plaster secondary impressions. A, tray pattern and tray; B, primary impression in place. The syringe is useful for filling the annular space between the natural teeth and the tray, in this case, around the molars. C, A plaster secondary impression in place on the patient's right side taken on a soft-metal tray as constructed, Figs. 34, 35 and 35A. On the left side the plaster is about to be placed free-hand, using the syringe without the coffer as shown in Fig. 43, 4, but first a small, soft metal vane is cut to the most suitable form, and is attached to the primary impression with wax or plasticine in the most suitable position for the purpose of making a favorable fracture of the plaster of the secondary impression. D shows the plaster, which has just been applied freehand both to the anterior teeth and to the molars. Note that the plaster is applied to both sides of the vane, which shows distinctly in the picture. E shows the following: reading left to right, molar impression cut with Gritman plaster knife, as shown, then fractured, and then reassembled in the tray; the anterior plaster impression removed in two pieces; and the buccal half of the left molar impression, and also the vane removed, leaving the lingual half remaining yet in the mouth. F, Impression re-assembled. Note that this is the same impression as in Figs. 2, 7, 12, 16, 22, 31, 39, 40 and 42.

diverge from the path of insertion or removal.

Impressions with multiple paths of insertion and withdrawal of its parts. The presence of remaining natural teeth on

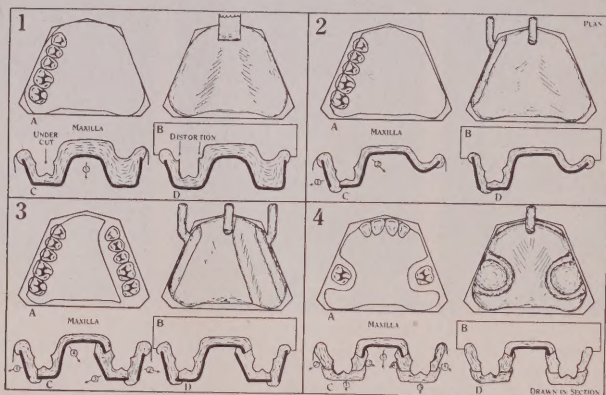
of the necessity of a greater number of sections in a sectional or primary-secondary impression, as may be noted in Fig. 51, section 3. In the same Fig. 51, section 4, may be noted another complication,

FIG. 50



A sectional impression: The equivalent in a sense of the primary-secondary method described here, in which compound is used exclusively. (A) The case for which the impression is to be taken; (B) the primary and secondary impressions both completed, with the primary impression still in the mouth, as it appears during the taking of the secondary impression; (C) both impressions removed from the mouth; (D) impression reassembled outside the mouth.

FIG. 51



Primary-secondary impressions in modeling compound (sectional method*) showing single, double and multiple paths of withdrawal, corresponding in number in each case to that of the primary plus the secondary impressions. In each section of the drawing, the figured arrows show the order and direction of the withdrawal of each part of the impression, which is, of course, the reverse order of that of the taking of the impression. Also, in each section, A represents the study model with the outline of the primary tray; B represents the complete impression in place; C represents a sectional drawing of the complete impression in place; and D the impression reassembled outside of the mouth, and poured, with the boxing removed.

Section 1 shows a single modeling compound impression, which is inserted and withdrawn in a single path corresponding to the long axes of the teeth. With undercuts about the gingiva, this will distort the impression, as shown in B. It is very rare that such an impression may be taken without distortion, and that is when the teeth are conical in shape, which is not normal.

Section 2 shows the same case as in section 1, taken in two parts, a primary impression covering all but the buccal surfaces of the teeth; and a secondary impression, covering

* The term *sectional impression* implies merely an impression taken in sections. The term *primary-secondary impression* is intended in this article to express in a general way a primary impression which covers either the mucosa to be used in mucosa support, or the occlusal surfaces used in root support or both; and one or more secondary impressions which follow, merely to take the undercuts.

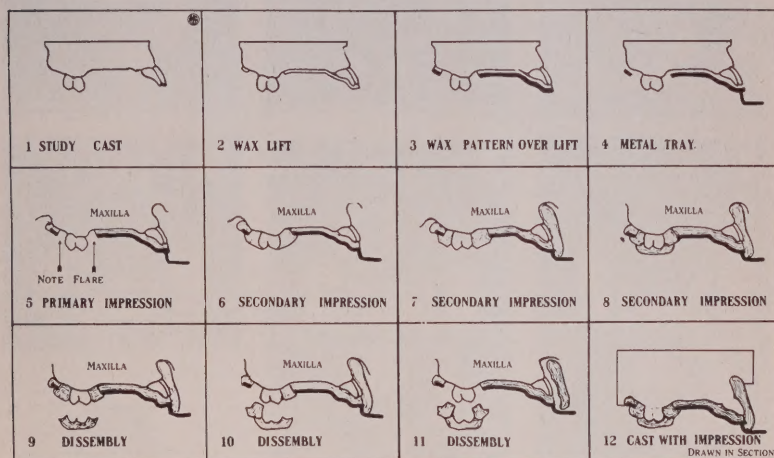
the buccal surfaces of the teeth only. Each of these two sections is withdrawn obliquely and in the order as noted in the drawing.

Section 3 shows a somewhat similar but different case in which two sections, each with a separate path of removal, as in section 2, is impossible because of the teeth on the patient's left side standing in the way. As a result, four impressions are necessary; namely, a primary impression, as shown in outline at A, with three secondary impressions, each having a separate path of removal as indicated at C.

Section 4 shows an impression having isolated teeth with an undercut around the entire circumference of each tooth at the gingival margin. This is the identical impression as shown in Figs. 2, 7, 12, 16, 22, 31, 39, 40 and 42, 51 (sec. 4), 52 and 53, but in which the secondary impressions are now all taken in modeling compound.

As is shown in Fig. 52, the primary impression, having been completed and securely held in place and moistened with a suitable oil, the compound secondary impressions about the molars are built up to the occlusal surfaces only. These are of course locked in place, as is also the primary impression. The impression is then completed by oiling and applying compound to this section and to the labial of the incisors; and, after the whole is hard and cold, it is removed as in C, fracturing the pieces marked 2-2 and 4-4. This fracturing is also shown in Fig. 52, spaces 10 and 11.

FIG. 52



An anteroposterior section of the impression shown in Fig. 51, section 4, having both primary and secondary impressions of modeling compound. This drawing up to section 5 is identical with Fig. 2, which latter continues on showing the secondary impression taken in plaster. There are undercuts around the molars. 6, The first piece of modeling compound of the secondary impression applied about the molar; 7, trimming the first piece to expose the occlusal surface. This is, of course, done in the mouth. The secondary impression on the labial aspect is now applied. 8, After oiling the first piece, the second piece is applied over the molars; 9, 10 and 11, stages in disassembly of the secondary impression. In space 10 the first piece applied in space 6 is chilled and fractured in order to remove it. 12, Assembly of impression with cast poured and boxing removed.

Note. It may readily be seen that the impression will come away from the cast in the same manner as it came away from the mouth and in a fit state for reassembly, and hence for making duplicate casts if desired.

namely, mesial and distal undercuts in conjunction with buccal and lingual undercuts.

Modeling compound, when cold and hard, will fracture with quite as clean a

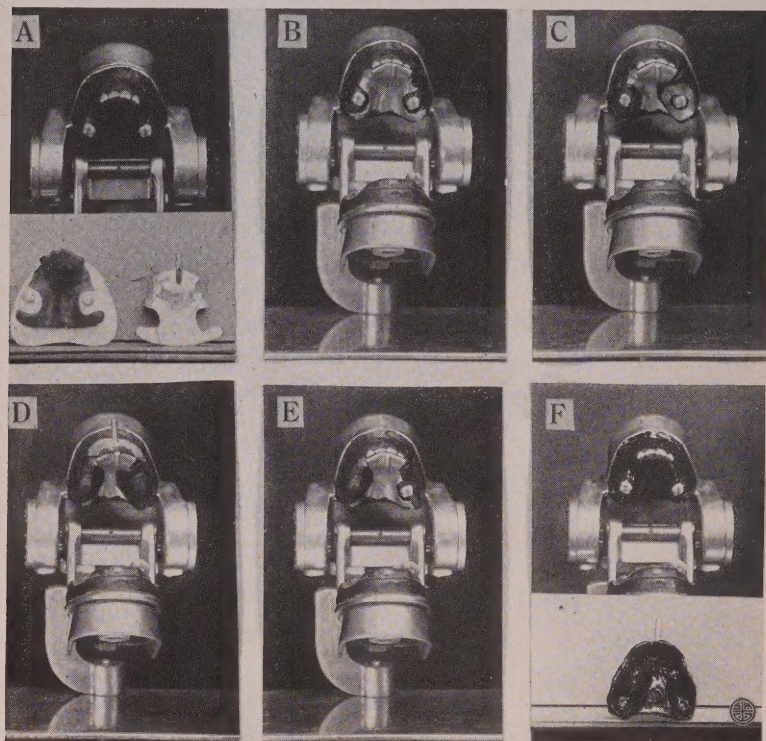
break as will fine plaster. This makes possible a primary-secondary modeling compound impression as in Figs. 52 and 53, the latter of which is a photograph of the familiar impression shown in Figs.

2, 7, 12, 16, 22, 31, 39, 40, 42, 51 (section 4), 52 and 53.

A short method of molding and casting flat trays for buccal secondary im-

example, Fig. 50 and Fig. 51, sections 2 and 3. A short method of molding and casting such a tray consists of cutting and fitting the wax pattern to form,

FIG. 53



A photograph of the stages of the impression shown in Fig. 52. A, Wax pattern, study cast and tray; (Note that the tray covers the entire lingual aspect of the anterior teeth, differently from Fig. 49, section B, in which plaster is used for the secondary impression); B, primary impression complete; C, first parts of secondary impression applied to molars, one trimmed and the other untrimmed, the left molar showing the tray used, an annular piece of air-chamber metal; D, second parts of molar impressions and anterior part applied; E, anterior part and second part of molar impression removed; F, half of the first part of one molar impression fractured and removed; F, impression reassembled.

pressions. A flat tray with a handle is often useful to take the impression of the buccal side of a series of teeth, or, for that matter, any similar surface, as, for

bending it flat, and casting it against a flat piece of wood, using only the drag of the flask, then rebending it to shape, will be noted in Fig. 54.

The Lower Impression, Mucosa Support

37. THE LOWER IMPRESSION, MUCOSA SUPPORT. THE PRIMARY LOWER IMPRESSION (BY THE DENTIST), MOLDING AND CASTING THE TRAY (BY THE ASSISTANT)

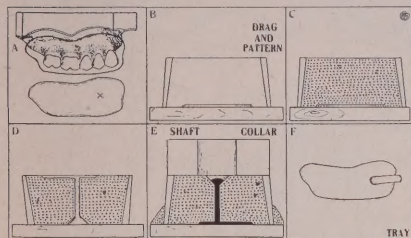
From Fig. 55 will again be noted one difference between molding the upper and the lower trays, due to the space between the distal extremities of the lower impression. This drawing shows the drag with molds made by patterns of both an

lower with undercuts, marked with arrows.)

Were this to be molded in the ordinary way on the study model and lift, difficulty in a bad parting of the sand, in spite of the parting medium (French chalk), would occur, as in D and E.

Even were it possible to successfully bed the pattern in the drag as at F, a wrong parting would occur from the undercut still present. To obviate this, a number of expedients may be used, among which are decreasing the depth of the lingual flanges, and, as shown in G,

FIG. 54

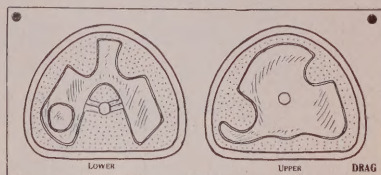


Short method of molding and casting flat trays for buccal secondary impressions: A, upper part of drawing, outline of tray; lower part, the wax pattern cut to shape and flattened out on the bench; the mark X shows where the handle of the tray is desired; B, the flat pattern laid on a flat piece of wood with the X upward, then dusted with French chalk, after which the drag of the Bailey flask is laid on; C, showing the sand packed in; D, the drag is then inverted, and the pattern removed; the sprue is cut with the cork-borer at the place in which the mark X is printed in the sand; E, tin poured in; F, the sprue becomes the handle, and both the handle and tray are bent to form as shown.

upper and a lower tray. In the center of each is the sprue hole, cut with the cork-borer, but in the lower, two supplementary gates are cut to connect the sprue with the mold. A safety-razor blade answers well for this purpose.

Frequently undercuts toward the posterior end of the lingual flanges of trays for lower jaws will occur, a condition not usually found in upper jaws. (Fig. 56, sections A and B, with wax pattern and lifts, and C, wax patterns showing the

FIG. 55



The difference in molding between an upper and lower tray is that an auxiliary sprue must be cut, preferably with a safety-razor knife. (See Figs. 8A and 9.)

adding wax or plasticine between the lift and the tray, then softening the wax pattern of the tray and refitting, as in lower part of G; and, after casting, bending back to the original form, as drawing, upper part of G.

In larger lower trays and in order to keep the parting line from being too steep, the large flask is desirable. Section H shows the pattern in G in the drag of the large flask as described in Figs. 14 and 15.

The difference in incline of the two parting lines from these two patterns, which are identical, may be seen by comparing the dotted lines representing the parting lines of the Bailey flask (section F), and in the large square flask (section H). There is also more room around the pattern for manipulation. A slight disadvantage is that it requires slightly longer time to fill the large flask with sand.

38. THE PRIMARY LOWER IMPRESSION; SEATING THE IMPRESSION (BY THE DENTIST)

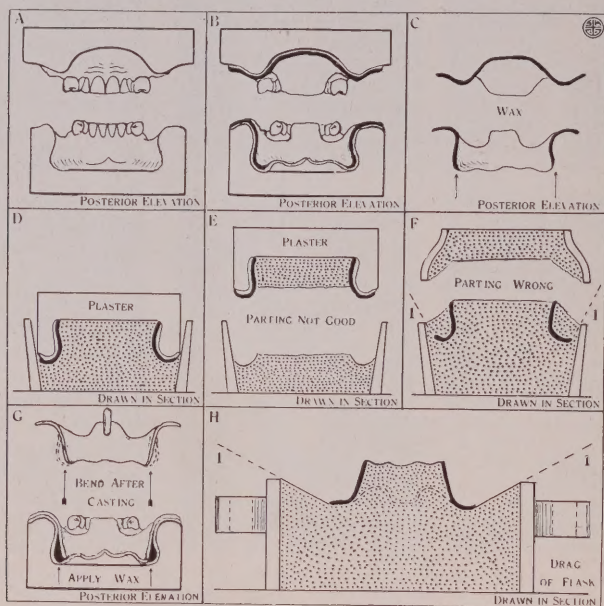
This is done by adding a film of, and then tracing on, modeling compound as already described for the primary upper impression, Figs. 21 and 24. The impression is now taken, then removed, and deficiencies traced on, reheated over a flame or with a Hanau blowpipe, dipped in water at 150°F., and returned to the mouth, as described also for the primary

subsequent steps of muscle-trimming may be subdivided into individual and successive steps, as advocated by whichever of the well-known authorities on modeling compound technique as may be preferable to the dentist.

39. THE LOWER SECONDARY IMPRESSION (BY THE DENTIST AND ASSISTANT)

Generally speaking, there is very little difference between the secondary impres-

FIG. 56



How to avoid a minor difficulty in molding lower trays as described in the text.

upper impression (Fig. 25 and accompanying text).

The process is continued until the impression is seated. Subsequent to this, any muscle-trimming may be done, and it is also possible to make application of certain of the principles of retromolar retention should this be desired, as in full lower impressions.

Also, as in the primary upper impression, the technique of seating and the

subsequent steps of muscle-trimming may be subdivided into individual and successive steps, as advocated by whichever of the well-known authorities on modeling compound technique as may be preferable to the dentist.

Impressions for Root and Combination Supported Partial Dentures

40. DR. ROACH'S TECHNIQUE* FOR ROOT-SUPPORTED DENTURES

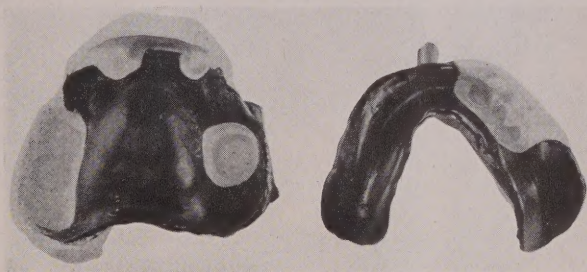
In the judgment of the writer, no contribution toward the solution of the problem of impression for the construction of root-supported dentures (including bridges and partial denture restorations) has exceeded in value that of Dr. F. E. Roach of Chicago. It is simple, accurate, rapid, positive and comfortable for the patient, and requires less skill and judgment, in direct contrast with the present more or less hit-or-miss method of a quantity of plaster or its equivalent in a large tray, and the difficulty and un-

surfaces already established, with the occlusal surfaces of the remaining teeth, which method eliminates all of the uncertainty of the fracture over the usual method of a single plaster impression. This is clearly shown in Fig. 58, section G.

41. GELATIN-BASE IMPRESSION MATERIALS

Within the past few months, an impression material called "Dentocell"† has been introduced to the profession, having, it is claimed, sufficient elasticity that it will rebound or spring into its original position after having been removed from

FIG. 57



Two other impressions reassembled: Note closed and open perforations in the primary impressions.

certainly of its subsequent removal in a suitable state for reassembly.

The method is, like the foregoing, a primary-secondary method, but one in which in a sense the order is reversed, that is, in the Roach technique, the occlusal surfaces of the teeth are taken in plaster in the primary impression, and the mucosa surfaces and the teeth, except the occlusal surfaces, are taken in plaster in the secondary impression.

The convenience and accuracy of this method are realized on removing the primary impression, for there lie the secondary impressions with their parting

undercuts. It is described by the makers as "hydro-colloidal" and is said to be composed of gelatin, cotton flock (finely ground cotton) with a percentage of thymol and oil of wintergreen.

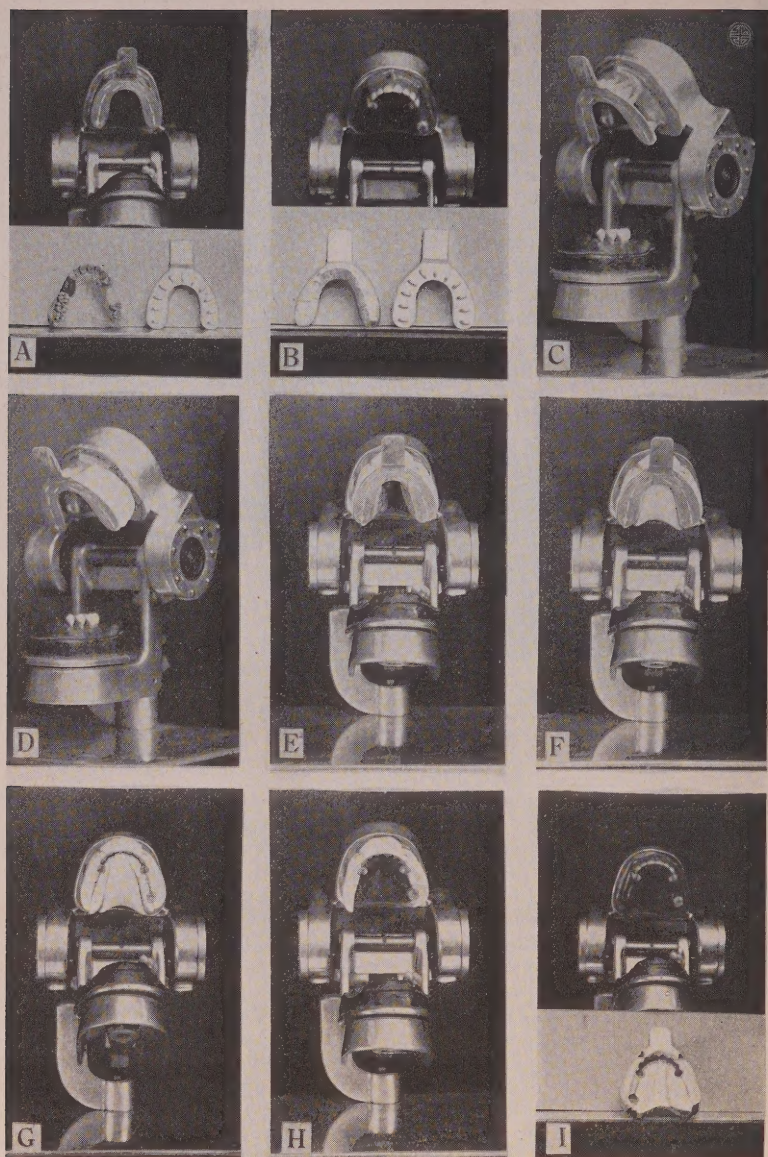
It is prepared in cartridge form, softened by boiling three minutes, mixed, cooled to a suitable temperature, and ejected into perforated impression trays from a double-plunger syringe‡ shown in Fig. 58 A, sections A and B with space in the tray for ample material about the undercuts, after which the impression is inserted in the usual way, cooled to a proper temperature and then removed. No separating varnish is required. To

* A detailed account of this impression technique from the pen of Dr. Roach may be obtained from the Thomas J. Dee Company, Chicago, Ill.

† De Trey Bros., Zurich, Switzerland.

‡ One of these plungers is for mixing the material, and the other is for ejecting it.

FIG. 58



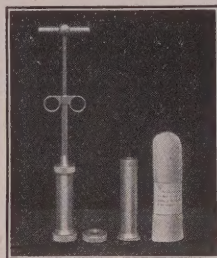
The Roach impression method for root-supported partial dentures as briefly described in the text: A, Model of mouth used to show the method outside of the mouth and the Roach occlusal tray, also showing a type of core on another model, for shaping the primary

impression between the teeth; B, the primary impression is shown in position after trimming; C, primary impression, trimmed ready for secondary impression; D, buccal section of the secondary impression in position; E, buccal, labial and lingual sections of the secondary impression in position with the primary impression in place; F, buccal, labial, lingual and palatal sections of the secondary impression in position; G, primary impression removed, leaving buccal, lingual and palatal sections of the secondary impression in position; H, lingual and palatal sections of the secondary impression removed; I, sections removed from model of mouth and reassembly of impression. It is understood that the different sections of the impression are coated with a suitable separating medium as required.

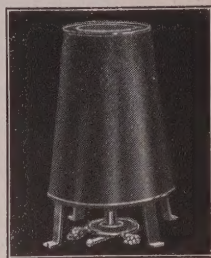
FIG. 58A



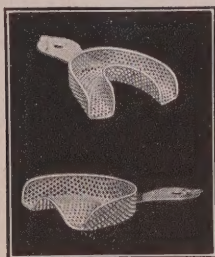
A



B



C



D



E

Apparatus used for manipulating the gelatin-base impression material "Dentocoll" by the De Trey Bros., Zurich, Switzerland.

- A. A container, with the material in cartridge form.
- B. Syringe with mixing and ejecting plungers, used for preparing the material for use, with a felt sheath useful during manipulation.
- C. Boiler, for heating and softening the material in the syringe.
- D. Perforated impression trays.
- E. Desiccator used to keep the impression in moist air before pouring.

prevent evaporation of the water content of the material the impression should be kept in a moist atmosphere. A desiccator shown in Fig. 58, A, Space E, is useful for this purpose.

While it is not possible, because of a lack of clinical experience and of scientific tests, to accurately forecast the value of this principle in impression taking, yet at this time it appears that the proc-

ess here outlined is of especial value in orthodontia and for partial impressions for root-supported cases. So far as is known it is not possible to muscle-trim and post dam the impression, hence the apparent contra-indication in its use alone for mucosa supported partial dentures and full dentures.

Also, it has developed that the material adheres to modeling compound; and

for that reason it may be applied in a layer on a modeling compound impression, which, after it has been removed from the mouth and enlarged somewhat over the surfaces which have not taken undercuts, and enlarged considerably over surfaces which have taken undercuts. The compound impression, with its lining of "Dentocoll" is then returned to the mouth, in a somewhat similar manner as the so-called "plaster wash" impression, and removed when the lining material is in its proper condition for removal.

It is quite probable that this original material, "Dentocoll," may be the first of a series—for it is reasonable to assume that its appearance will stimulate research and invention along these lines. The manufacturer's directions for the use of "Dentocoll" here follow:

Heating and Mixing:

- (1) Prepare the syringe by unscrewing the end cap and pulling back mixing handle and ejecting handle to their fullest extent.
- (2) Remove the wrapping from a stick of Dentocoll, insert the stick in the syringe and replace cap.
- (3) Place the charged syringe in boiler containing already boiling water (the water should not be allowed to come over the barrel of the syringe).
- (4) After boiling for a period of 3 minutes remove the syringe and, holding it in the sheath supplied, work the mixing rod approximately a dozen times, after which return to boiler for further heating.
- (5) After further boiling for a minute or so, remove the syringe and again work mixing rod; the material is now ready for cooling.

Cooling:

- (6) To cool Dentocoll, place the syringe for a period of 10 seconds in tepid water, after which remove and again work mixing rod until the internal heat is felt through the barrel of syringe.
- (7) Continue this until the syringe can just be held against the cheek. Generally speaking, three immersions in tepid water for the period stated above are sufficient to reduce the material to working temperature. Gradual cooling is essential for an even mix. The material is now ready for ejecting into

the impression tray. Special perforated impression trays are supplied for impressions with Dentocoll.

Filling the Tray:

- (8) Pull back the mixing handle and ejecting handle to the fullest extent. Unscrew bottom cap and, pushing forward handle, eject a small quantity of material into the tray first. Distribute the Dentocoll over the tray, pressing well through the perforations to ensure retention; now eject the bulk quantity until the tray is filled and conform to tray, smoothing the surface with a little vaseline on the ball of the finger. For lower impressions where a smaller bulk of material is required, screw on the spare cap supplied to reduce the diameter of the material ejected. It is advisable to warm this reducing cap before screwing to position on syringe.

To Reduce Time in the Mouth:

- (9) Immediately before inserting the tray into the mouth, instruct the patient to rinse out with cold water, during which the back of the impression tray is held in cold water approximately 5 seconds. This shortens the time in the mouth, controls the direction of the flow, and generally stabilizes the impression in the mouth.

Taking Impression:

- (10) Insert the impression tray in the mouth and gently press into position. Only light and slow pressure should be employed.
- (11) Hold the impression tray in the mouth for 3 minutes, during which time it should be syringed with cold water. . . . When sufficient teeth are present to hold the material, after one minute cooling the hand holding the tray may be removed. This leaves both hands free for subsequent syringing of labial and buccal borders.
- (12) Under no circumstances should the impression be forced out of the mouth. The removal of the impression is best accomplished by freeing the buccal borders with the fingers. This breaks the atmospheric pressure, when the impression may be gently removed.

Pouring Impression:

- (13) The impression should be washed under the cold water tap and poured immediately. If this is not possible it should be placed in a glass airtight container. (The Dentocoll impression must on no account be left exposed,

as loss of water content through evaporation is followed by contraction.)

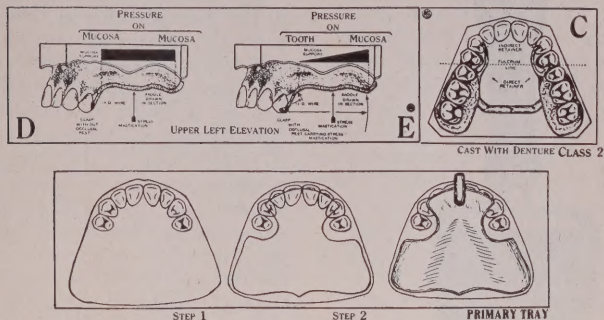
Removing From Plaster Cast:

- (14) Dentocoll impressions are removed from the plaster cast without the use of hot water, and, if removed carefully, other models may be obtained

42. IMPRESSIONS FOR COMBINATION SUPPORTED DENTURES

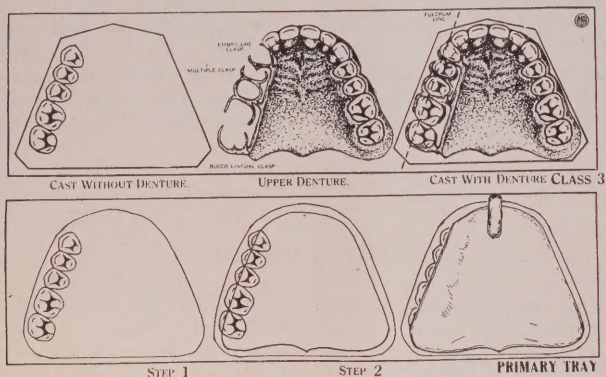
Partial dentures may be supported by (a) the mucosa alone; (b) the roots alone (for both of which impression methods have been described); (c) a combination of these two.

FIG. 59



An example of a combination supported denture with the rotation axis coincident with the fulcrum line as described in the text.

FIG. 60



Another example of a combination supported denture, with the rotation axis coincident with the fulcrum line and with the development of the tray, showing the tray finished. The impression (reversed) for this may be seen in Fig. 50.

from the same impression. When a duplicate model is not required, the tray is first released, after which the Dentocoll impression may be quickly broken away.

- (15) Wash Dentocoll impressions under cold water tap for each subsequent pouring.

Combination support in partial dentures, as now understood, most frequently involves a rotation movement about the teeth chosen to provide the root support.

In Fig. 59 may be seen a plan (c) of a combination supported denture. In E

may be noted the rotation, for one end rests on the comparatively immovable

FIG. 61



A paperhanger's seam roller, extremely useful in rolling strips or sheets of plasticine. Use cylindrical form, as above, not barrel form. (Illustration supplied by Ridgely Mfg. Co., Springfield, Ohio.)

teeth by the occlusal rests, while the other end rests on the more or less compressible mucosa. Therefore under the

load in mastication there must be a slight rotation, in this case with fulcrum line (the dotted line in c) as the axis of rotation, and as noted with curved lines in the elevation of the restoration at E. D shows the same restoration without occlusal rests, a type of design suitable should the bicusps be considered unable to support an additional load; in this case the load is transferred entirely to the mucosa; also in this case there is a bodily movement toward the mucosa and not a rotation. Below may be seen the steps in outlining the primary tray, also the primary tray finished.

Regarding the impression for this type of restoration, for the present it may be proposed that the foregoing methods for mucosa and root support may be, in a sense, combined with the object of giving an impression which will compress the tissues as they will be compressed under the future denture during function.

Therefore the primary impression in Fig. 59 is applied to the teeth (the anteriors) and to the mucosa, so that the load will be applied similarly to that of the future denture.

Figure 60 will illustrate the development of a tray for the primary impression in another combination supported denture. The impression in two parts will be seen in Fig. 50.

Making the Cast

43. THE CAST; REASSEMBLY AND BOXING (BY THE ASSISTANT)

Each of the foregoing types of impressions are made with the main surfaces for reassembly predetermined, namely, those between the primary and the secondary impressions. Those secondary impressions which are broken apart in the mouth are comparatively small, and ordinarily fracture readily and definitely, all of which makes reassembly comparatively accurate, positive and easy. Reassembly should be done at once.

The secondary impressions are reas-

sembled, then attached to the primary with sticky wax, and the whole is boxed according to ordinary methods, using plasticine, rolled with a seam roller, Fig. 61, or wax or sheet lead, as indicated in Fig. 62.

For boxing the lower impression, plasticine may be pinched between the wings of the impression as noted in Fig. 63.

44. SEPARATING MEDIA (BY THE ASSISTANT)

For the purpose of preventing adhesion between cast and impression, a form

of separating medium is ordinarily necessary. Three of the most popular forms

formula for an aqueous solution of shellac here follows:

Water Shellac Varnish

Best gum shellac	2 oz.
Borax	1 oz.
Water	 $\frac{3}{4}$ pt. or about 14 fluid ounces

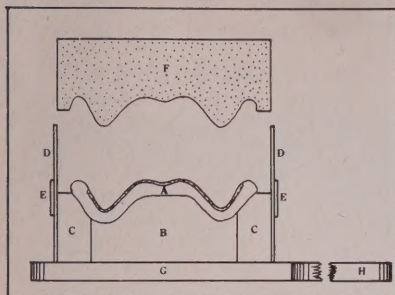
Use boiling water to dissolve the borax, and then pour slowly into a wide-mouthed bottle which contains the gum shellac. Stir and keep well stoppered.

Dr. Rupert Hall's ethereal solution intended for dipping impressions is made from Squibb's collodion thinned by equal parts of alcohol and Squibb's ether (with sufficient gentian-violet for color) to such a consistency that a "green" impression, when dipped and the excess drained off, shows no loss of fine lines.

Perhaps the oldest and in a sense the best separating medium for partial denture impressions, as described by Dr. Lester Furnas in the *Dental Summary*, 1924, at page 738, is a 25 per cent solution of gum shellac in ethyl alcohol with a little gentian-violet for color (solution A); this is followed by a 25 per cent solution of gum sandarac, also in ethyl alcohol (solution B), after which is used a soap film. Dr. Furnas writes:

"The principle upon which these solutions work is as follows: Solution A, when painted over the plaster of Paris

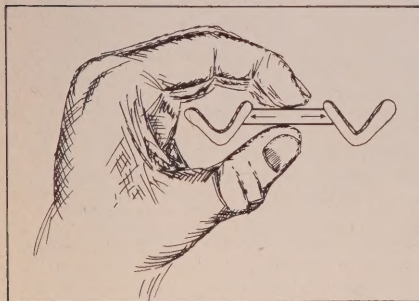
FIG. 62



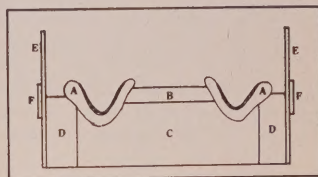
Diagrammatic illustration of "boxing" an upper impression: (A) Impression dipped or coated with suitable separating medium; (B) cone of plasticine; (C) strips of plasticine allowing periphery to project perpendicularly and horizontally $\frac{1}{8}$ inch past the impression; (D) soft metal rolled to 20 gage; (E) elastic, binding all together; (F) finished cast, which includes the impression of the lips and cheeks for about $\frac{1}{8}$ of an inch past the periphery. This is sometimes called "cheek fit," and is of considerable importance in securing peripheral valve seal.

are (a) aqueous solutions, (b) ethereal solutions, and (c) alcoholic solutions. A

FIG. 63



A



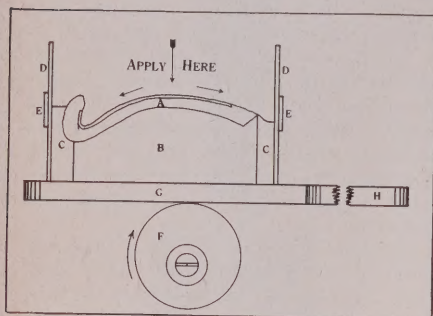
B

Boxing for full lower impression: The main point of difference between the boxing for lower and upper impression, Fig. 62, is the plasticine sheet, which, A, is cut to approximate form and expanded by pinching against the side of the lower impression and is then supported by soft plaster; B, then the boxing is completed the same as the upper. The removal of the boxing after the initial set and the trimming and final removal after hard set is identical with the upper.

impression, is at once absorbed into the dry plaster of Paris. The alcohol content soon evaporates, leaving the shellac as a hard filler. This acts as a foundation for solution B. When solution B is applied the minute openings of the plaster of

ing medium can be applied before the impression is boxed, provided it has had sufficient time to dry, and the operator prefers this method, but the separating medium should not be applied while moisture remains on the plaster of Paris.

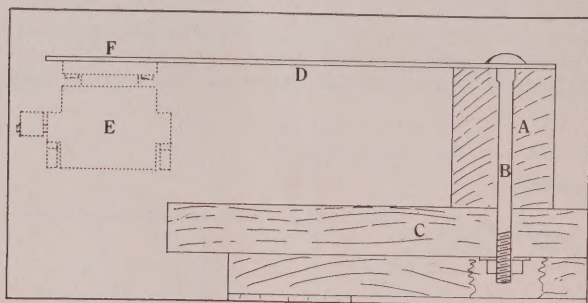
FIG. 64



A simple vibrator consists of two parts: (F) A stone out of true or a hexagon nut, or something similar; (G-H) a wooden paddle. Arrows indicate application and direction of flow of material.

"After solutions A and B have each been applied and each allowed to dry thoroughly, the boxing is next filled with water and allowed to stand for from five to fifteen minutes. This water is then poured out and the impression coated with a heavy coating of soap-suds. A convenient method of applying the latter is to have an old glass or cup in the bottom of which is a cake of heavy laundry soap (not toilet or liquid soap), and in this an old shaving brush or a small varnish brush. When the soap is needed the brush is dipped in water and a lather or suds is worked up after the manner in which a barber makes a lather. This is then applied to the boxed impression and the brush returned to the glass until it is needed again. The soap-suds are now immediately flushed out of the boxing,

FIG. 65



A simple electric vibrator, which will accommodate impressions, and also larger pieces, as, for example, vulcanizing flasks as described in the text.

Paris surface have been filled by the shellac in solution A so that it cannot penetrate. It therefore remains on the surface and as the alcohol evaporates, leaves a hard, smooth, glazed surface. This serves to transmit a like hard smooth surface to the cast. The practice of using just the sandarac or just the shellac is wrong, because either alone will not give the desired results. The separat-

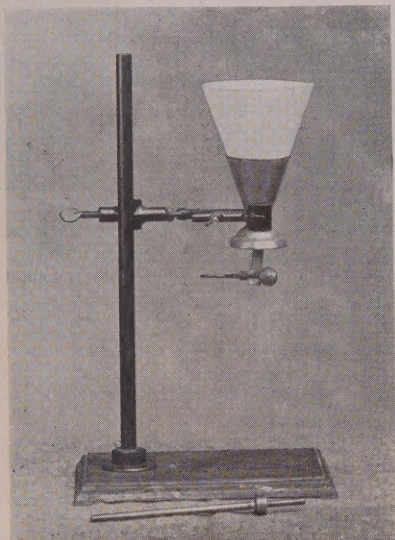
ing medium can be applied before the impression is boxed, provided it has had sufficient time to dry, and the operator prefers this method, but the separating medium should not be applied while moisture remains on the plaster of Paris.

"The total thickness of these coatings just as described when placed on micrometer will measure less than one ten-thousandth of an inch and will make no difference in the adaptation of the finished case."

45. FILLING THE IMPRESSION (BY THE ASSISTANT)

The material used for making the cast is preferably one of the so-called stones. The ordinary precautions should be used

FIG. 66



A simple dispenser for plaster for filling impressions in which a fluid condition of the mix is permissible, as, for example, in casts not to be subjected to pressure. This stand is made from a laboratory iron support with a rectangular base (Cenco No. 13036)* and a Burette clamp (Cenco No. 2840). The clamp grasps a holder with a Vortex 12-ounce paper drinking cup; to this cup a $\frac{1}{4}$ inch rubber tube is fastened by plasticine, using an attaching tool similar to that described in Fig. 48; a pinch-cock tubing clamp No. 2886 is used to control the flow of material.

After use, the paper cup may be thrown away and the rubber tube cleansed for further use.

in introducing this material into the impression. Figure 64 shows an effective aid, an eccentric on the electric polishing lathe, and Fig. 65 a brass plate bolted to

the bench, and carrying a small fractional horse-power motor of the Hamilton-Beach or Dumore type, also bearing an eccentric, which causes both motor and plate to vibrate according to the revolutions per minute of the motor. The sizes of the brass plate, hardwood block and bolts here follow:

One brass plate, 14 inches x 6 inches x $\frac{1}{8}$ inch.

One hardwood block, 6 inches x 3 inches x 5 inches (D6S).

Two carriage bolts with washers $\frac{3}{8}$ inch x 7 inches.

One eccentric, made from $\frac{7}{8}$ inch brass rod, $\frac{1}{2}$ inch wide, and hole for motor shaft drilled $\frac{1}{8}$ inch off center.

For convenience in filling impressions in which the plaster or stone material used may be applied to the impression in a sufficiently fluid condition, a dispensing stand is shown in Fig. 66. The use of this stand permits a flow of the material the diameter of the inside of the rubber tube, which is used at a rate from a single drop to a steady stream.

46. DUPLICATE CASTS FROM PRIMARY-SECONDARY IMPRESSIONS; REMOVING THE IMPRESSIONS FROM THE CAST

Duplicate casts are highly desirable for records either in private practice or research work. The primary-secondary impressions here described, if each part of the impression coming in contact with the cast material is properly prepared with a suitable separating medium, lend themselves admirably for the duplication of casts. For example, to avoid the necessity of softening the compound with heat, a suitable varnish, with a vegetable oil, as olive or cocoanut oil, may be used as a separating medium. As for the plaster parts, a proposed treatment of these has just been described.

In any of the impressions here illustrated as, for example, those in Fig. 51, sections 2, 3 and 4, will be found that after pouring the cast, the several parts of the impression may be removed piece by piece from the cast as they were previously removed from the mouth, and in good condition for reassembly.

* These numbers refer to the catalogue of the Central Scientific Co., Chicago, manufacturers of laboratory supplies.

Conclusion

47. THE MASTERY OF ADDITIONAL DETAIL REQUIRED IN THIS TYPE OF IMPRESSION MORE THAN JUSTIFIES THE TIME GIVEN BY THE CERTAINTY IN RESULTS

To those naturally disposed to view innovations with a certain degree of timidity, the additional detail and the time which appears to be involved in methods here described may seem prejudicial to their practicability from an economic standpoint. The main answers to this point of view are as follows:

(1) *For the dentist:*

(a) Each step is definitely completed before the next is begun, and the result is therefore certain, eliminating such element of chance as that of the impression of parts not being secured, as might happen in a single plaster impression; and also eliminating the inherent inaccuracies of the single modeling compound impression.

(b) The fractures or planes of separation in the impression are largely predetermined and not left to chance.

(c) Possibilities of coöperation with assistants.*

(2) *For the patient:*

Comparative lack of discomfort because of the small bulk of both the primary and secondary impression.

(3) *For successful results:*

(a) Favorable seating conditions secured for the denture, with conditions favorable to the health of the subjacent tissues.

(b) Utmost extent of base area is secured for the denture.

(c) Compression of tissue at gingival margin of remaining teeth is avoided.

(d) Adhesion may be had if desirable for retention.

(e) Retention may be secured in the retromolar region, using technique similar to that for full lower dentures.

(f) Accurate impressions are obtained of occlusal surfaces of the remaining teeth, as used in fitting various types of occlusal rests.

(g) Accurate impressions are obtained of the crowns of the teeth, making it possible to successfully survey these for clasps, when this is desirable.

A situation in engineering which parallels and in a sense justifies the present-day tendency toward more time and care on impressions for full dentures, with the great improvement in results and practical elimination of adjustments and makeovers, is that of the time and care given to making forms for reinforced concrete building construction.

To one accustomed to watching brick construction it must seem a vast amount of labor necessary to construct the forms for the concrete. But when a whole story of a building is poured in one operation, with the result of a single unit of material rather than the countless units were brick used, the parallel, to one having had experience in both types of impression making for partial dentures, is decidedly obvious.

Returning to prosthetic dentistry, it will be remembered that the standard practice in full denture service two decades ago, was a single uncorrected and untested impression consuming but a few moments' time.

At the present time the standard practice in this branch is a fully corrected and tested impression, returned to the mouth a number of times, and consuming the best part of an hour. Such an impression has more than justified the time given by the certainty in results.

The problem of impression taking in partial denture service may be solved in like manner.

In concluding this report on the study of impressions, the writer desires to acknowledge his indebtedness to the various manufacturers who have supplied illustrations, and to Farmer Bros. and the Department of Photography, University of Toronto, for photographic assistance, and to Miss Marjorie Cummer for assistance in some of the later drawings: to Mr. W. V. Byrne of the Faculty of Dentistry for assistance in preparing material; and to those who have been

* Paragraph 6.

his teachers (both through the literature of dentistry and through their personal instruction) whose names are synonymous with advancement in dental pro-

thesis: to the late Dr. J. W. E. Monfries of Adelaide, Australia, and especially to Dr. Robert J. Reade of Toronto for his valuable assistance in revising the text.

Supplementary Note*

48. MOLDING AND CASTING THE SPECIAL TRAY IN PLASTER OR IN AN INVESTMENT MOLD RATHER THAN IN CALCAR

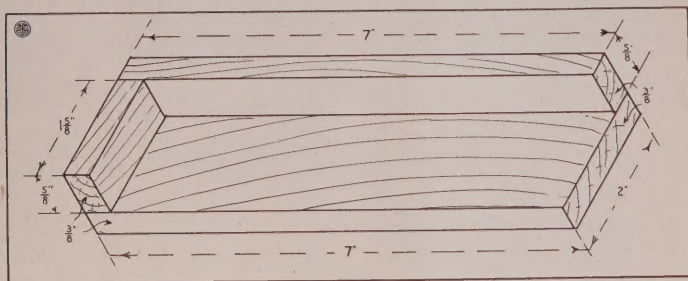
In the studies to which this note is supplementary the writer has made reference to this method of the investment mold as being alternative to the casting of the special tray in Calcar or, for that matter any suitable molding sand (Paragraph 20). The reason for this molding method is the shorter time consumed.

particular method as used by Dean Walter M. Bartlett of St. Louis appears with two illustrations in Prothero's book on "Prosthetic Dentistry."[†]

49. A RECTANGULAR MATRIX WITH A UNIVERSAL ADJUSTMENT WITHIN ITS LIMITS FOR MAKING PLASTER MOLDS

To reduce the time taken in trimming the plaster mold by hand and to produce a square base necessary to maintain the

FIG. 67



Dimensioned sketch of wood pattern for universal rectangular matrix. This wooden pattern is the first step in constructing a rectangular metal matrix. Any patternmaker, cabinetmaker or carpenter can make it of suitable wood from the above sketch. The wood pattern is then taken to the brass foundry, four brass or aluminum alloy castings are made from it, thence the machinist, where the castings are dressed square, which with four clamps completes the mold. Figure 69 shows the use of the mold.

It has since become apparent that to many dentists who employ assistants, or who wish to use their time between appointments for this purpose, a note on casting trays in plaster or in an investment material rather than in Calcar would be of value in these studies.

This method of casting trays in plaster has been in use for a considerable period of time, and a description of the

mold in an upright position during the pouring of the molten metal, a rectangular matrix may be used, the details of which may be noted in Figs. 67, 68 and 69. A lower tray made in this manner is seen in Fig. 70, with the plaster matrix in which it was cast.

Should it be desired to duplicate the tray or to make provision against a failure in casting, it is possible to preserve

*DENTAL COSMOS, Vol. lxxi, January 1929.

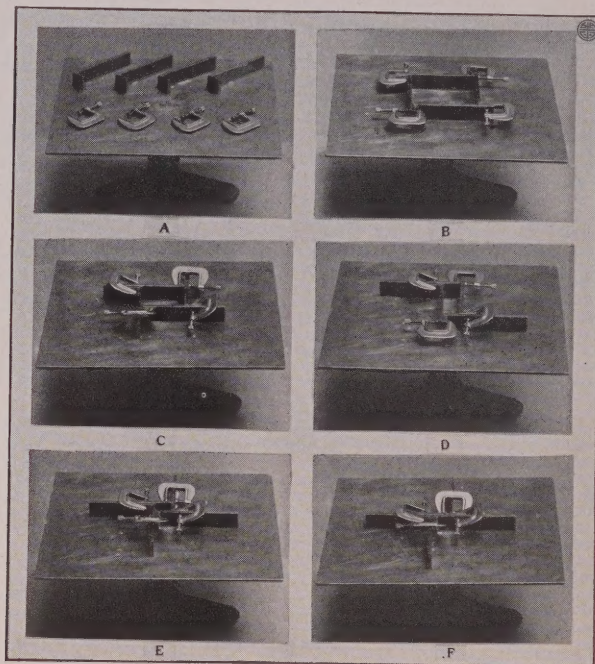
[†] Second edition, p. 39.

both the wax pattern and the mold. The wax pattern, however, must be formed so that the mold will separate readily, and without fracture of the wax or the mold. This fracture is caused principally by the position of attachment of the handle of

for vulcanization, which will of course result in the loss of the pattern and the partial or entire loss of the mold after casting.

In order to get a successful casting, the mold must be dry.

Fig. 68



The principle of a universal rectangular matrix. Four L-shaped pieces will make, if clamped together as above, a rectangular matrix with an infinite number of forms and sizes ranging from full capacity to zero: A, The component parts of such a matrix (four brass L-shaped pieces, with the arms of the L 90° to each other, and four clamps); B, the matrix set at full capacity, square; note that the short arm of the L is clamped to the long arm in this and each succeeding example; C, the matrix set at one-quarter capacity (square); D, the matrix set at one-quarter capacity (oblong); E, the matrix set at one-sixteenth capacity (square); F, the matrix set at zero capacity.

The principle is used in Figs. 67 and 69. Here it will be noted that that L-shaped pieces are so made that two different heights of matrix can be obtained. Note the lesser height in Fig. 69, B and C, and the greater height in D and E.

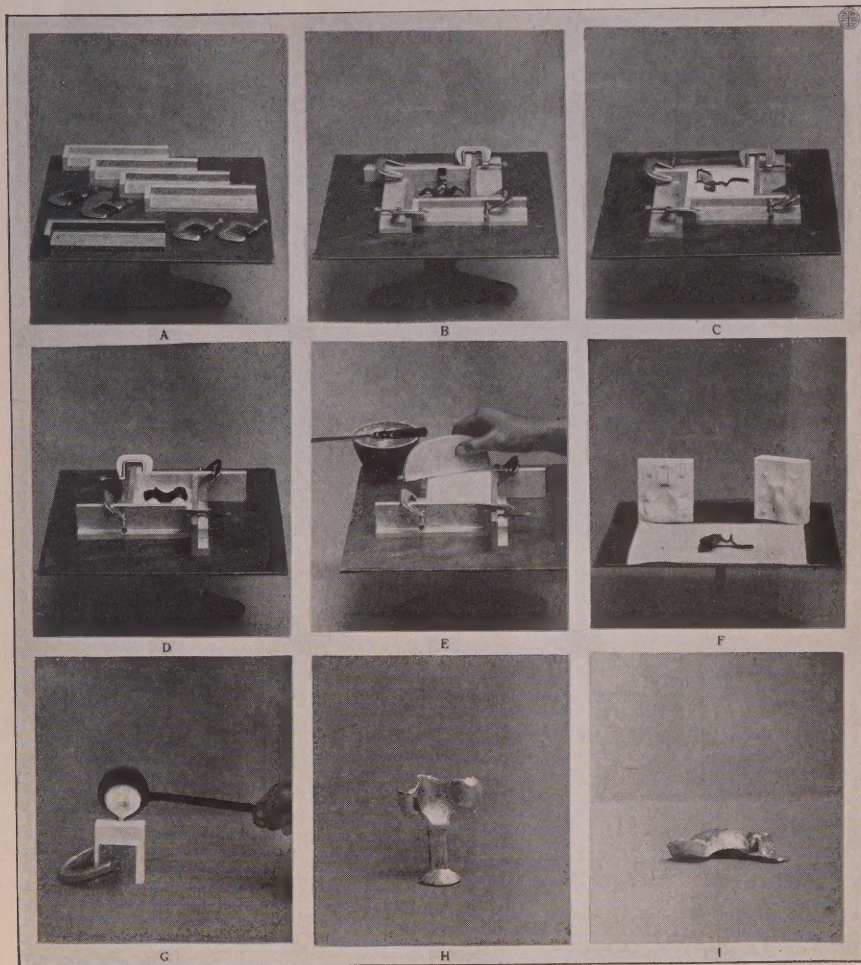
the wax pattern, which should be at the periphery rather than in the body of the tray, as in Fig. 71.

Should there be no desire to retain pattern or mold, the pattern may be waxed, invested and separated with heat similarly to the ordinary process employed

50. CASTING SPECIAL TRAYS OF TIN BY GRAVITY IN A PLASTER OR INVESTMENT COMPOUND MOLD MADE FROM A DISAPPEARING WAX PATTERN

It is also quite possible to make a wax pattern of a special tray and cast it by

FIG. 69



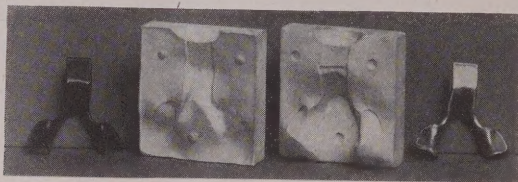
Molding and casting a special impression tray, using a two-part mold formed in a universal rectangular matrix of two dimensions. A brass table may be used for a working surface as shown above. A, Wood pattern (below left) as per sketch Fig. 67, with four brass castings above (finished on six sides) and four clamps (Stearns Handy Clamp No. 15, Fig. 45A); B, matrix set for first investment with at least three-eighths of an inch space around the pattern; C, first investment of wax pattern completed, with lesser height of matrix (oiled for separating purposes); D, matrix set for second investment, with greater height of matrix used; E, finishing the second investment, levelling off the plaster; F, both halves of the investment separated; wax pattern of the future tray removed; G, shows the halves of the matrix clamped together, and the pouring of the tin into the matrix, which is of course previously dried; H, the casting after removal from matrix; I, the completed tray.

pouring, using commercial tin. This pattern, however, must have auxiliary air escapes or vents. Any flask sufficiently large for casting full dentures will answer. The process is shown in Fig. 72, using a large Kerr casting flask. The wax is eliminated by the usual heating method, or if necessary by reason of the size of the mold, the wax may be eliminated by boiling in water. The mold being thoroughly dried and barely warm, the metal is poured in as in Fig. 72, F. Pattern and mold are, of course, both lost in this process, and must be remade in case of failure.

51. A SPECIAL FLASK FOR INVESTING TRAYS TO BE CAST BY THE DISAPPEARING WAX PATTERN METHOD

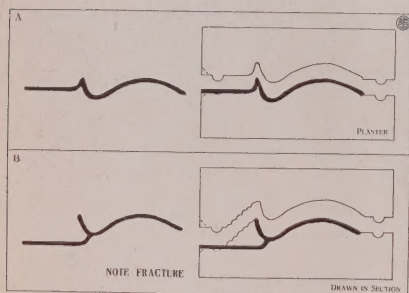
A dimensioned sketch of a flask* designed specially for this purpose may be seen in Fig. 73. Figure 74 shows the stages in the process of investing and casting. The principal advantages of the flask are that it is in two parts and that it is readily demountable, thus permitting easy removal of the investment compound matrix after casting, as seen in Fig. 74, G. The flask has a stud fastened to its side to make it convenient to tilt

FIG. 70



Showing a finished wax pattern with the halves of a matrix and a finished lower tray, made by the same process as shown in Fig. 69.

FIG. 71



If it is desired to retain the wax pattern and the mold, there should be no undercuts in the matrix.

A, An example of a matrix without an undercut around the handle, which is secured by inserting the handle at the periphery of the tray (as also in Fig. 69, F and I).

B, If the wax handle is attached to the body of the tray pattern in the usual position, either the pattern or the matrix (as shown above) or both will likely be fractured. If not, the mold would be assuredly fractured on the removal of the metal casting as in B.

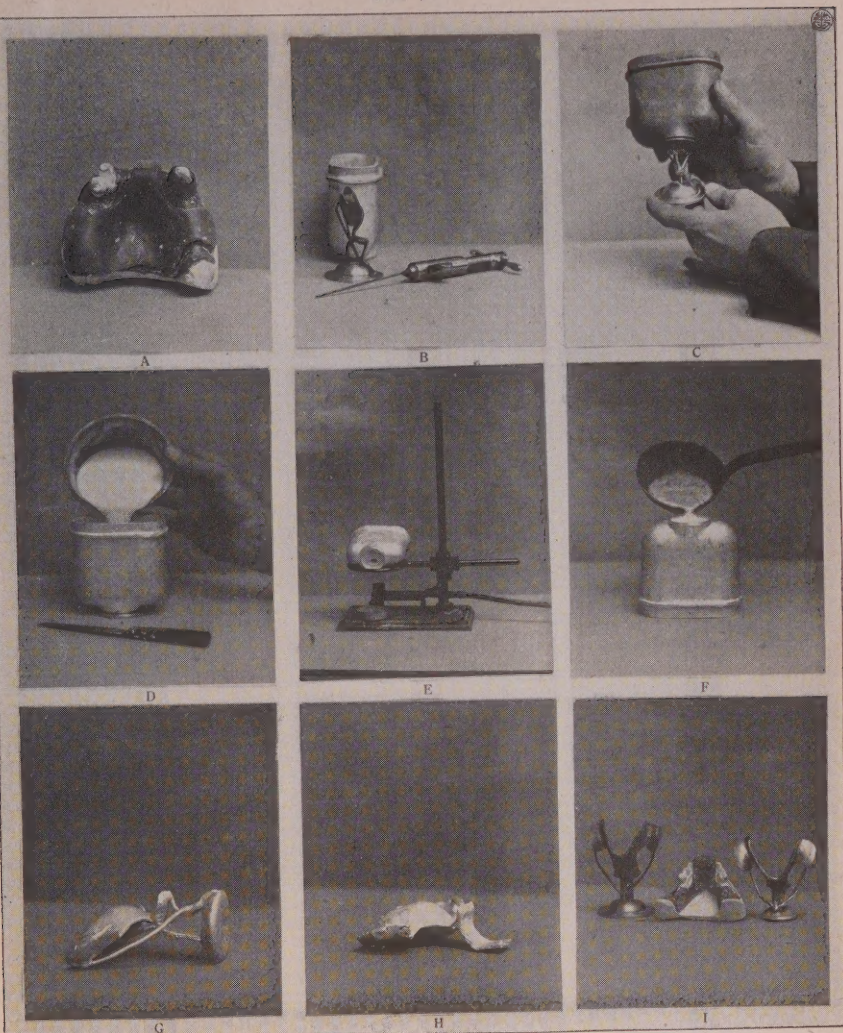
the flask during wax elimination, as shown in Fig. 74, E. A suitable crucible former may be made from the bowl of an ordinary tablespoon cut from the handle, as shown in Fig. 74, A.

52. TECHNICAL DETAILS RELATED TO THE FOREGOING PROCESSES

(a) *Wax pattern.* As in any cast-metal tray made by any of these processes, parts of the wax pattern which are weakened by necessarily narrow design must be reinforced, and every precaution must be taken to avoid stretching the wax, as considered in Fig. 6 and accompanying text. Base-plate wax stretched thinner than the original thickness is apt to make too constricted a mold for the molten metal to penetrate, with the results of a corresponding deficiency in the casting.

* So far as the writer's knowledge goes, there is no flask (with perhaps the exception of the Watts' flask, which being designed for casting denture bases, is rather small), at present available which is entirely suitable for this work; hence the design proposed.

FIG. 72



Investing and casting a special impression tray in an investment matrix in a standard casting flask with a disappearing wax pattern, somewhat similar to inlay work except that the metal is merely poured into the mold and not forced by centrifugal or other means: A, a wax tray pattern mounted on a crucible former (note the Marthews wax wire former in the foreground, with the nozzle removed in order to form thick wax wire, as seen protruding; wax wire is used for the vents, as described in paragraph 52, section b); B, wax pattern mounted on a crucible former as above; C, a flask from the Kerr casting machine is here used; owing to the shape of this flask, it is convenient to attach the pattern to the crucible former as above; D, investing; E, drying out; for convenience in quickly eliminating the wax before it can seep back into the investment, it is recommended that the flask be tilted; the drying out should be begun as soon as the investment has barely set; F, pouring in the tin; G, casting removed and untrimmed. Note the position of the vents; H, finished tray; I, the lower wax pattern on a cast; the same mounted on a crucible former, and a finished casting.

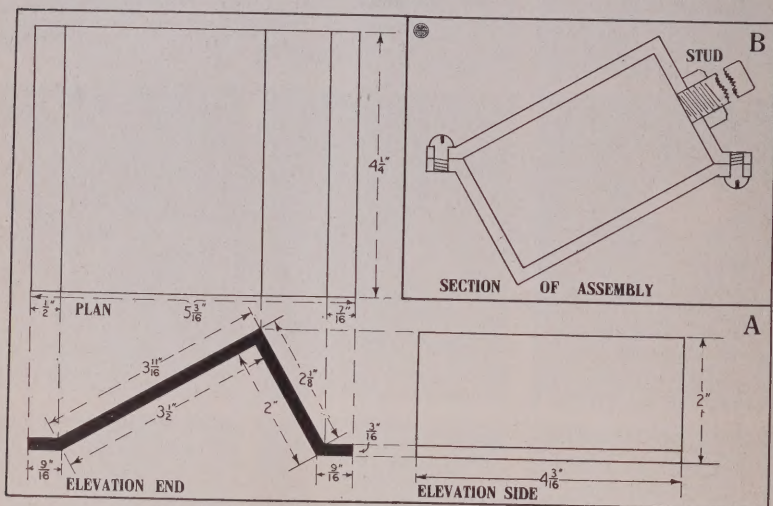
(b) *Escape of air.* Adequate provision should be made for the escape of air, because of the fact that the molten tin must fill the mold by its own weight, unassisted by pressure or centrifugal force, and because of the comparatively large volume of air to be displaced, along with a comparative lack of porosity of the mold.

Two suggestions are offered to secure

water content, and therefore a rapid elimination of moisture. A porous investment should not be used with the hope of thus eliminating air, because vents are a more positive means of elimination. The writer has so far preferred an investment of equal parts of plaster and coarse silic.

(d) *Mold temperature.* A mold cooled so that the touch of the hand is not un-

FIG. 73



A dimensioned sketch for a wood or metal pattern suitable for making a demountable square casting flask, as seen in Fig. 74. Figure 73, B shows a section through the finished assembly. A competent pattern-maker will make the pattern from a sketch as above; then the pattern is taken to the brass foundry and two castings are made from it. These castings are then taken to the machinist, who will assemble them as in B, and according to the following instructions. The dimensions of the stud are optional, but the writer suggests a $\frac{1}{2}$ " x 3" round brass rod. The screws suggested are $\frac{1}{4}$ " x 20 (threads) round head. The use of this flask is shown in Fig. 74.

this escape of air: (1) Vents made by means of wax wires (Figs. 72, B and legend) attached to the part of the pattern corresponding to the point of entry of the metal; and (2) vents which are attached to that part of the pattern *highest above* the part corresponding to the point of entry of the metal. Examples of the results both in the use and neglect of such vents are seen in Fig. 76.

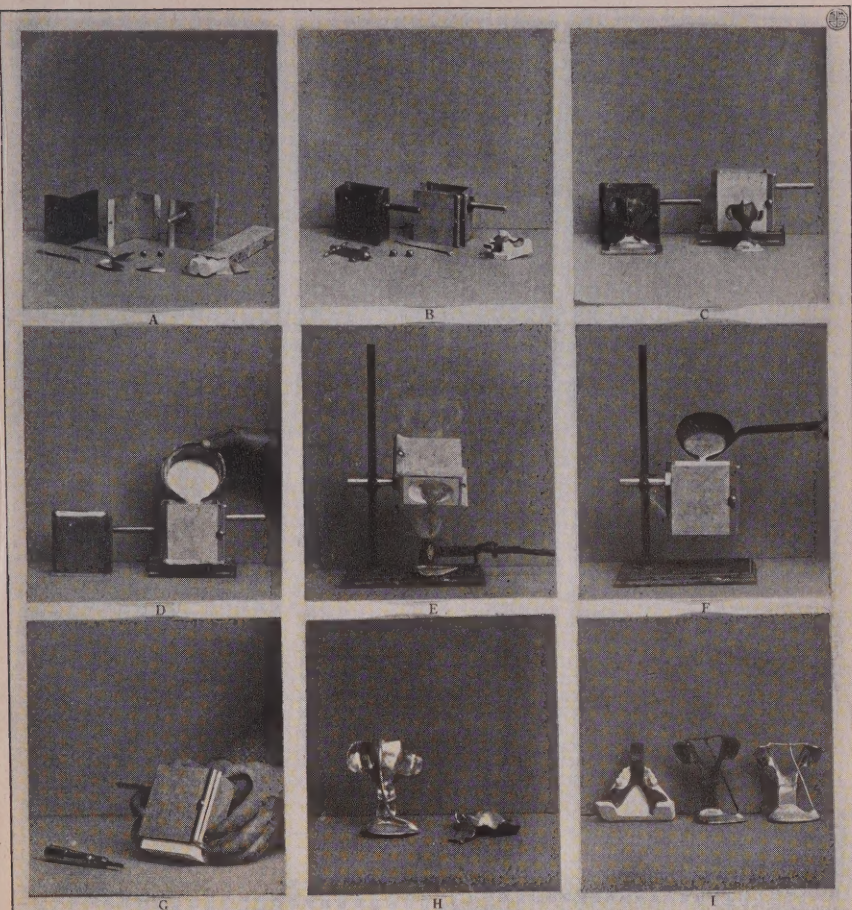
(c) *Investment.* Regarding a suitable investment material for casting trays, it should be remembered that a non-porous investment means a comparatively low

comfortable, say, 110° to 125° F., appears to be the most suitable for giving a clean bright casting. A hot mold usually gives a dull and discolored casting.

53. CONCLUDING NOTE ON THE TECHNIQUE OF TRAY CASTING

The writer's preference is decidedly in favor of the use of the molding sand method, as described in detail in the first part of this series of articles, because of the shorter time consumed, namely, seven minutes against one hour and twenty-five minutes required for the disappearing

FIG. 74



A demountable flask designed for casting special impression trays and its use.

A, From left to right, the flask pattern painted black, as per sketch, Fig. 73; two dessert spoons, one with the bowl cut off the handle, which bowl is used as the crucible former; the halves of the flask with assembling screws (and with the stud attached to one half of the flask); a box of Harbutt's plasticine.

B, Brass and aluminum flasks. The aluminum flask, with screws removed, demounted. A Marthews wax wire former is seen in the left foreground, and next is a piece of wax wire tipped with plasticine, which later is used to form a vent, while a tray pattern also tipped with plasticine is seen in the right foreground. It will be found more convenient to attach the tray and vent wire to the crucible former with plasticine rather than with wax. For this reason both are tipped with plasticine before being mounted on the crucible former.

C, Two wax patterns mounted ready to invest. Note they are conveniently fastened to the crucible former by plasticine. Note the vent wire starting from that part of the pattern which is most distant from the point of entrance of the molten metal, and carried to the anterior flange in order to prevent an air trap. (See Fig. 76 and legend.) In Fig. 74, H, may be seen more clearly the metal which fills this vent. Figure 74, C shows two wax patterns. That on the right mounted on the bowl of a dessert spoon; that on the left mounted on a crucible former made of brass of the size to fill the bottom of the

flask.* The plasticine mounting permits readjustment of the wax pattern on the crucible former, so that the flask will slip over it without interference. On the right side again is seen the spoon bowl used as a crucible former.

D, when the spoon bowl is used, a glass slab should be placed under it and the flask as shown. There will also be noticed a rope of plasticine so placed as to prevent a leakage of the investment. On the left is a filled flask used with the brass crucible former, mentioned above.

E, An iron support No. 13036 C (with rectangular base $5\frac{1}{2}'' \times 9''$ and rod $\frac{1}{2}'' \times 24''$) used with a clamp holder No. 2914, capacity $9/16''$. These may be seen separately in Fig. 75. They serve to hold the flask by the stud above the flame in a suitable position for eliminating the wax. If the elimination is done immediately after the investment sets, the wax will be expressed without seeping back into the investment, and will be expressed bodily as shown and may be conveniently caught in a suitable receptacle. It is not convenient to eliminate the wax at once, the filled flask should be kept immersed in water until a convenient time for eliminating the wax, when the same result as regards seepage will be obtained.

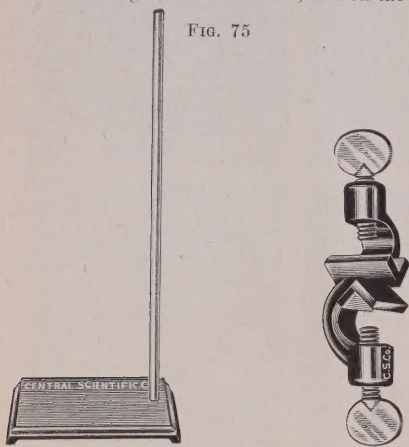
F, After both wax and moisture are eliminated and the flask is sufficiently cool to handle, it may be turned into a position for pouring the metal, as shown, by readjusting the clamp holder. The metal is then melted in a small iron ladle and poured.

G, Removing the investment; to do this the flask is opened by loosening the screws and tapping sufficiently to release the investment.

H, Two finished castings; one trimmed and the other untrimmed.

I, On the left is seen the wax pattern; in the middle the wax pattern mounted, showing the arrangement of the vent; and on the right the untrimmed casting.

FIG. 75

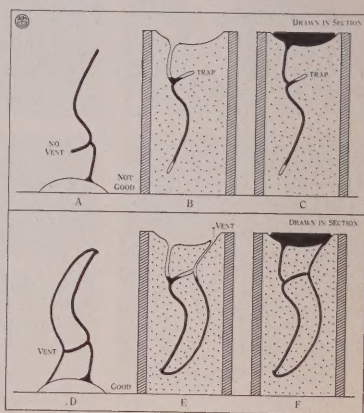


The iron support, rectangular base No. 13036 C, and the Clamp holder No. 2914, capacity $9/16''$, as made by the Central Scientific Co., of Canada, Ltd., 119 York Street, Toronto, Canada, shown in Fig. 74, E and F, and described in the accompanying legend.

mold technique. But it must be admitted that the latter has a place for those who for various reasons prefer it, and also very occasionally for difficult patterns.

In conclusion, the writer again desires to thank those whose continued assistance has in a large measure made this effort possible.

FIG. 76



The use of vents in casting trays. This is necessary to prevent air being trapped in the mold and thus spoiling the casting. A, Section of a wax tray pattern without a vent, mounted on a spoon bowl crucible former; B, shows the condition of air being trapped when no vent is used; C, the pouring of the metal is here completed, but the air is still trapped; result, a deficient casting; D, section of a wax tray pattern same as at A, but with a wax wire vent as in C and H, Fig. 74; E, at the moment at which air is trapped in B, there is no trapping of air in E, because the vent allows it to escape; F, finished pouring, showing the success of the casting due to the vent.

* The brass crucible former is made as follows: Make a wooden base to suit the bottom of the flask; then attach to it the dessert spoon bowl. This assembly becomes the pattern which is sent to the brass foundry.

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The Canadian Dental Research Foundation

is the official Research Organization of the Dental Profession in the Dominion of Canada, two Directors being appointed by the Dental Board of each Province, and two Directors, ex-officio, by virtue of their office in the Canadian Dental Association.

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Any Dentist in Canada who feels that he has any original work worthy of publication is requested to forward it to the Foundation.

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- Nos. 3 and 4—The Dentinal-Cemental Junction; Histological and Histopathological Studies of the Dental Pulp, May, 1922, H. K. Box. (60 pages, 82 Illustrations.)
- No. 5—The Science and Practice of Partial Denture Service, with Special Reference to a Graphic Method of Design, May 1922, W. E. Cummer. (27 pages, 16 Illustrations.)
- No. 6—Combinations as an Aid in the Discovery of Fundamentals in Dentistry and Other Sciences, May, 1923, W. E. Cummer, G. R. Anderson, Robert J. Reade. (71 pages, 120 Illustrations.)
- No. 7—Studies in Periodontal Pathology; The Mechanics of Occlusion, Summary of the Signs of Incipient Periodontal Disease (Issued in Conjunction with the Department of Health, Province of Ontario), May, 1924, H. K. Box, G. R. Anderson. (120 pages, 135 Illustrations.)
- No. 8—Articulation for Partial Dentures with the Snow Apparatus and Wadsworth Incisor Guide, June, 1924, W. E. Cummer, I. H. Ante, J. A. Bothwell. (45 pages, 39 Illustrations.)
- No. 9—Combinations which occur Between the Upper and Lower Six Posterior Natural Teeth in Occlusion (supplementing Bulletin No. 6), June, 1924, W. E. Cummer, G. R. Anderson, Robert J. Reade. (18 pages, 13 Illustrations, including folded Chart.)
- No. 10—Treatment of the Periodontal Pocket (issued in conjunction with the Faculty of Dentistry, University of Toronto), September, 1928, H. K. Box. (124 pages, 120 Illustrations.)

Special Cavity Preparations and Casting Processes for Gold Inlays

Including some of the physical phenomena
taking place in the materials used, and
methods of compensating for the
shrinkage of gold

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INTRODUCTION

IN presenting material for this bulletin, it is the writer's object to place before his fellow practitioners, the results of his efforts in devising a system of cavity preparation that would more fully meet the requirements of gold inlays in certain classes of cases where it has been found difficult of accomplishment by the old established methods.

Where teeth are built upon generous proportions, many of these old style methods may suffice. In some of the anterior teeth, pins have been resorted to, and with much success where the tooth substance was sufficiently thick to permit of their use. Under favourable circumstances dove-tails and grooves have given equal satisfaction.

But what dentist has not met with the problem of inserting a strong, efficient filling, in a small, thin lower incisor, without running the risk of weakening the tooth, or showing an unsightly amount of gold.

Because of difficulties of this nature, the writer set himself the task a few years ago, of working out some solution of this very perplexing problem. After much study and experimentation certain results were obtained which while not giving one hundred per cent. satisfaction, have in the hands of associates and the writer, given good results, and made the insertion of durable, artistic inlays in such teeth more easy of accomplishment. And it is with the hope that a report of these findings may be of use to those members of the profession who are looking for help along these lines, that this material is very humbly submitted for their consideration.

Whilst it is intended to be shown wherein this system may be of most service in certain special cases, an effort will be made to point out that it may be used to advantage under other circumstances.

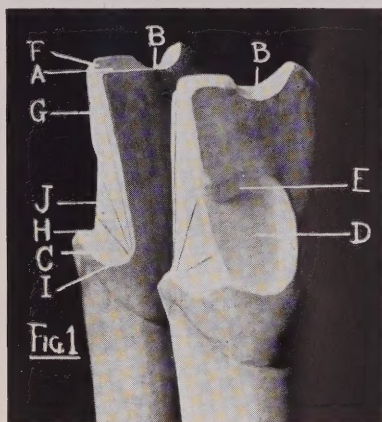
It is proposed also to give the writer's technique for the different steps in the development of the filling, going through the various stages from pattern making to the casting of the inlay. It is believed that by so doing, the benefits of these preparations may be more fully realized, and something of advantage passed along that may lend itself to more general application as well.

It is not expected that these ideas will revolutionize cavity preparation, nor that they will in very many instances supplant those methods that have stood the test of time. For it must be apparent to all that any method has its limitations and that this can be said of anything which has hitherto been taught along these lines.

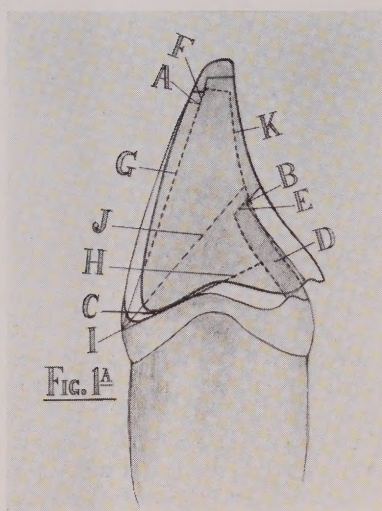
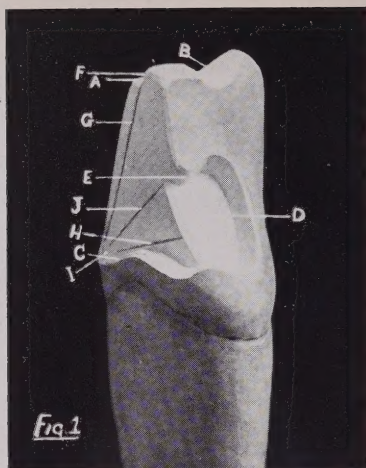
SPECIAL CAVITY PREPARATION FOR GOLD INLAYS IN LOWER INCISORS

Figure 1 represents a preparation in the mesial of a lower incisor, where the extent of caries necessitates the removal and restoration of the incisal angle.

Retention consists of (1) a step (A) at the labial, the upright wall of which prevents the tipping of the inlay towards the lingual—this being one of the chief directions of force exerted upon lower anterior's; (2) a notch (B) at the distal end of this ledge, for the purpose of resisting movement in the mesial direction; (3) A dove-tail (D) at the lingual, which also prevents mesial displacement, and at the same time holds the inlay down; thus overcoming any



tendency of the incisal portion towards tipping in the labial direction. (4) The saddle shaped gingival wall prevents any force exerted on the labio-gingival region dislodging the inlay towards the lingual, since the labial slope (C) would force the inlay to rise before it could move in that direction; and as the force brought to bear upon this position is of a minor nature, if at all, the additional hold of the cement is quite sufficient to obviate this difficulty. By referring to drawing 1A, the exact nature of such movement can be ascertained. It will be seen that it must rise on the gingival slope (C) sufficiently to allow the lingual dove-tail to disengage itself at (B) before the inlay can be lifted directly out. This in fact



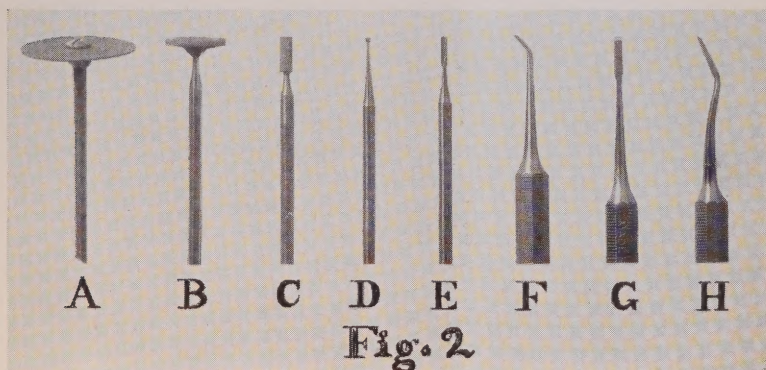
is the only way in which the inlay can be displaced. Thus it will be seen that the inlay cannot be displaced in any direction by any force likely to be exerted even when the test is made before the additional retention of the cement is added.

Rarely should inlays depend upon cement for retention to any marked extent; and never should they be expected to be held in place by this means alone. With this in view an attempt has been made in the example shown and those following, to work out retention that would hold the inlays in place by mechanical means alone, when stress is brought to bear in any direction through the force of the bite. The cement should be thought of mainly as a sealing medium, and for resisting displacement in unlikely directions of movement; *i.e.*, against the force of the bite.

THE PREPARATION

The instruments used in the preparation of all cavities described are represented in Fig. 2. All sizes required are not shown, but they will suffice to illustrate those needed.

The cavity described above is prepared in the following manner: With wheel A, which is of the safe-side "Jo-dandy" type, a slice is taken off the defective mesial surface making the cut through from labial to lingual, taking slightly more off at the lingual to facilitate removal of the wax in that direction. If this cut cannot be made sufficiently deep to remove all decay, and thus give a perfectly flat proximal wall, after removal of the remaining carious dentine, a little cement can be inserted to fill up the depression. This should then be ground flush with the same instrument used in making the slice, or with a sand paper disk.



Before leaving this part of the preparation, much of the form of the gingival wall can be obtained by the aid of this safe-side disk; which should be manipulated in such a way as to cut down more deeply both to labial and lingual than at the centre of this wall, so as to follow the gingival curvature; thus forming a saddle-shaped gingival wall, which should be slightly beneath the gums. The balance of the shaping of this wall should be done with an inverted cone bur, No. 33½, by placing it into the dentine close to the enamel. Where broader gingival walls are found desirable, larger burs may be used. Starting near the crest of the saddle and holding the blades of the bur firmly against the enamel, the bur is guided and held steady by its contact with this harder tooth substance, and the cut can be made with certainty and safety. The hand-piece should be held in such a position that the end of the bur will be parallel to the desired plane of the gingival wall, which as stated should be sloping downward from its centre both labially and lingually, but horizontal in the mesio-distal direction. This will undermine the enamel, which as cutting progresses can be easily chipped away by a large hoe excavator F. This instrument can also be utilized to true up the whole gingival wall, using it as one would a chisel; or in some cases the latter instrument can be used to advantage for some of this work. This finishes two walls with the exception of a little trimming of the margins, which will be considered when the bevelling of the margins is described.

The next step will be to cut down the incisal edge. This should be done with the mounted stone B, cutting away about 2 mm., by revolving it across the cutting edge of the tooth, and extending it to within a short distance of the distal incisal angle, so as to include the distal developmental groove. As this part of the tooth is likely to wear at a downward slope in the labial direction, this new surface should be ground in a similar way to insure strength of gold for the protection of the cutting edge.

Much of the formation of the ledge A, Fig. 1, can be made with the same instrument by first grinding down the newly formed labio-incisal angle at a steep bevel, then by turning the stone so that it will run parallel to the incisal edge, forming the beginning of the ledge, which can be finished with the small mounted stone, (C), held in the same manner as the larger stone in its latter position, and the plain fissure bur No. 57. Whilst using this bur, or No. 56, make the notch B, leaving it level with the ledge.

Before discarding the larger stone B, used in this part of the preparation, turn your attention temporarily to the forming of the lingual dove-tail. With this stone grind the enamel off an area

corresponding as nearly as possible to the desired outline of the dove-tail. This can be done to advantage by revolving the stone crosswise the crown, and beginning at the lingual margin of the proximal cavity, proceed as far as feasible in the direction of the contemplated margins of this step (D). The remaining preparation may be done now, or subsequently to the completion of the incisal retention as the operator desires, by using in a contra-angle hand-piece, a stone similar to C, followed by an inverted cone or plain fissure bur—preferably the latter, as it will give straighter surrounding walls, and less under cuts. In each case the flat end of the instrument should be held against the axial wall. This rule may be varied however, as far as the inverted cone bur is concerned, where it is desirable to extend the margins in a manner similar to that described in the case of the gingival wall. Such instruments may have a tendency to “chatter” when used in this manner; but a good grasp of the hand-piece and a firm finger rest on a neighbouring tooth will do much to overcome this, and at the same time give both the patient and operator confidence, and prevent disastrous slips.

This dove-tail need not be very deep—just slightly into the dentine—but it must be made with care, and its form must be very definite. In addition to making it such a shape that the wax will draw (as is necessary in the case of all inlays), the incisal wall E, has a definite relationship to two other walls, namely, C and F. By examining drawing (1A) it will be seen that these two walls determine the movement of the wax pattern when being withdrawn from the cavity—the incisal portion moving upward on line F, and the gingival along line C. By extending these lines until they meet, forming the angle G, I, H, and bisecting this angle with the line J, the direction of wall E can be accurately determined. The incisal wall E should then be placed either on, or parallel to this bisecting line. This may not be mathematically correct, but it has proved to be sufficiently so for all practical purposes.

It is not expected that in each case such a method will be used to determine the form of this part of the cavity. We cannot draw accurate lines on the tooth in this way; but what is intended is that everyone shall understand the principle thoroughly, and then it will only need the judgement the average operator has at his command and a little careful calculation to arrive at the required result. In my humble opinion more operators have fallen down on this cavity preparation through either carelessness concerning, or lack of comprehension of this important point, than through any other technical difficulties. Students have been tested on this

point, and it has been found that the idea was grasped and put into practice with no more difficulty than when learning many of the old established rules of cavity preparation. Older practitioners, however, sometimes complain of its difficulties, when if they would go about it as faithfully as they once did in their student days, they would find it simplicity itself. But this is a digression, and the cavity preparation has not been completed.

After the use of the above named stones and burs in the shaping of the dove-tail, its walls may be finished with Black's hoe excavator 12,5,6 or 12,5,12 (F) using the cutting blade in a scraping motion to true up the irregularities, and sharpen the angles so as to give the maximum of retention and facilitate the removal of the wax. The incisal is the only wall of the lingual dove-tail that needs any special form—the others should be practically perpendicular to the surface, or slightly diverging.

This completes the cavity preparation with the exception of a slight amount of bevelling of the margins where it seems necessary. The lingual step can be freely treated in this particular. The lingual margin of the main cavity, the incisal and gingival margins, may all have a fair amount of bevel, as circumstances demand. The labio-proximal margin however, due to the particular movement of the wax during removal, must be treated very cautiously in this way, if at all. A very slight amount, particularly near the incisal is advised where the force of the bite is most apt to do damage; and does not seem to interfere materially with the removal of the wax, nor the fit of the inlay. This can all be done with the last named instrument (F) and with chisels. Stones and disks are not suitable as a rule, as they have a tendency to round the margins.

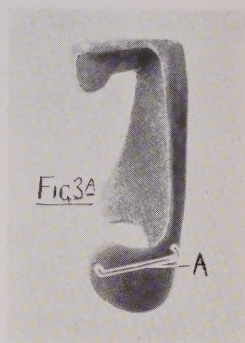
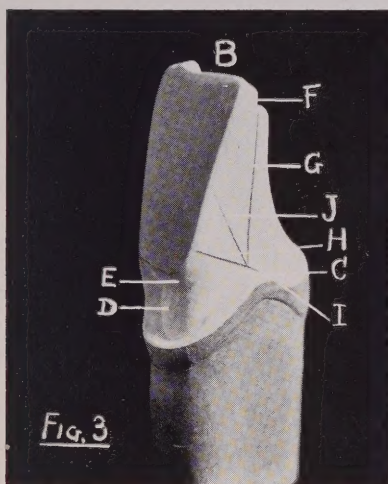
Whilst this preparation has been described as suited to small lower incisors, there is no reason why it cannot be adapted to any of the lower incisors, or cuspids. That should be left to the choice of the operator, for he may have other well tried friends that have stood him in good stead in such cases, and he would be unwise in dropping them where they have been found entirely satisfactory.

This particular form of cavity preparation is not indicated in upper teeth. Their greater size more frequently allows older styles to be used with satisfaction. And again the direction of the force of the bite being outward, does not call for the same method of anchorage.

Figure 3—a cavity preparation, also in a lower incisor—is but a modification of the last one described. It differs chiefly from the latter in that it has been prepared in reverse order.

A labio-gingival defect in addition to a proximal-cavity, was the chief factor in the choice of this form. There being such a defect on the labial, it was thought advisable to make the step D in that area, rather than in the much less susceptible surface on the lingual, thus "killing two birds with one stone" (and a few other instruments).

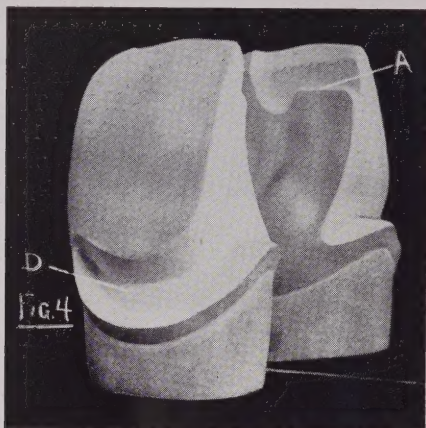
Another important difference, is in the form of the depression at the distal end of the incisal ledge Fig. 4, B. This does not run right through to the labial as in the case of Fig. 1, but is only cut in level with the axial wall of the ledge. This forms a hook on the inlay at this point, and is sufficient to prevent displacement in the



mesial direction. This is a preparation some men prefer, even when there is no cavity on the labial. Gold rarely shows at that point and there being less necessity of its showing at the incisal, due to the incisal ledge being at the lingual, the effect is therefore more in line with esthetics.

This form may be used to advantage not only in all lower anteriors, but in the uppers as well, (Fig. 4), if the circumstances are such that the appearance of gold would not be an objection. In the upper incisors and cuspids, it will be seen that it resists admirably the forces of the bite and as in the lowers where a labial cavity occurs as well as a proximal, the two cavities can be filled with one inlay, whereas by the older methods, the making of two separate inlays was required.

It is not the intention to advocate its use indiscriminately in the upper teeth. Only in certain special circumstances as mentioned, should it be chosen for such positions.



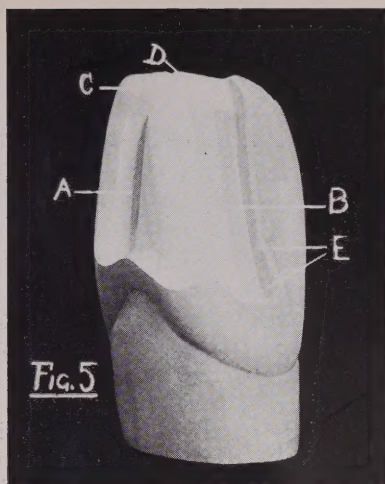
THE PREPARATION

This cavity is formed in a similar manner as that represented by Fig. 1, and with the same instruments. The labial step D, however, must be of a different shape from the lingual dove-tail of Fig. 1, since it should conform to the curvature of the gingival line. This form serves the same purpose as a dove-tail, since its curvature prevents displacement in the mesial direction. By referring to Fig. 3, it will be seen that the incisal wall E is far from lying on the bisecting line J, but is parallel to this line. If this point is carefully observed, there need be no difficulty in removing the wax pattern, the technique of which will be described later.

For small thin upper incisors, another type of preparation has been worked out which follows. Fig. 5 represents such a cavity in an upper lateral incisor, and is a modification of a three-quarter crown preparation.

RETENTION

The retention consists chiefly of two grooves, one (A), on the proximal surface near the labial dento-enamel junction, and the other (B), on the lingual, running from the gingival wall to near the incisal edge.



PREPARATION

The first step in the preparation will be to form a flat proximal wall and gingival saddle in a similar manner as that described for Fig. 1. Next with stone B, a thin layer may be ground from the lingual surface, extending from near the gingival to the incisal and to about the junction of the middle and distal thirds of that surface. The depth of this cut will depend largely upon the nature of the bite, which if not too close, may only necessitate the removal of little more than half the thickness of the enamel. In other cases the whole of the enamel may need grinding away in order to obtain strength for the gold and prevent interference with the bite.

The gingival and distal walls E should then be made about perpendicular to the surface, with inverted cone bur No. 34 and hoe excavator F, and the linguo-incisal ground with stone B to a very acute angle (Fig. 5, C) with the labial surface.

Only a very slight amount of gold need show at this edge, as the steep bevel toward the lingual will allow a considerable thickness of gold where it is most needed to resist the force of the bite. This thin edge must be made strong by grinding a narrow cavo-surface bevel (D) at right angles to the labial surface. All other margins may be bevelled in the usual manner, preferably after the completion of all other steps.

The lingual groove is first made with a plain fissure bur No. 56, holding it close to the distal wall E. This groove is then squared

up with a Black's hoe 8,3,6, or 8,3,12, using the full width of the blade, and cutting straight in until sufficiently deep to give good retention, which due to its length, need not be so deeply into the dentine as to imperil the pulp.

The proximal groove A, is made in a similar manner to the lingual, using a plain fissure bur. The gingival end of this groove may if the operator so desires for the sake of extra retention extend slightly below the gingival wall in the form of a pit. This half-round groove (A), is then made V shaped with the corner of a hoe excavator, for the purpose of making it more definite and of greater retentive value. At the same time care should be taken to make it straight and uniform so as to facilitate the removal of the wax.

After the margins have been bevelled, the cavity may be considered ready for the making of the pattern.

This preparation has been tried out by several confreres and students, and seems to have given much satisfaction in cases where the smallness and thinness of the teeth made them unsuitable for the usual type. They are easily prepared, do not weaken materially the teeth, retention is good, and the amount of gold showing may be reduced to the minimum.

Fig. 6 represents a similar preparation for use in thin upper centrals. It only differs from the last one described, in the extent of the lingual portion of the cavity. This being a much broader tooth, sufficient room for retention can be obtained without cutting past the centre of that surface, and in many cases even less will be sufficient.

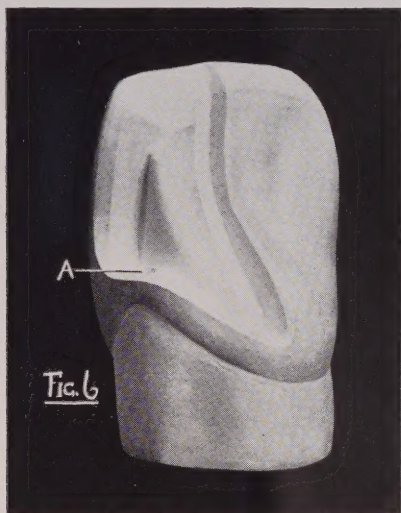
This being a larger tooth and consequently there being less danger of exposing the pulp through deep cutting, instead of the pit at the gingival end of the proximal groove, a pin hole (A), may be made in the gingival wall. This may also be used in some cases in upper laterals as well. It is especially indicated where, due to depth of decay in the proximal portion of the cavity, it is difficult to get a satisfactory groove. It is however, not often necessary under other circumstances.

Before leaving this particular preparation, it might be well to emphasize the importance of making both grooves very definite and true. Grooves made simply with fissure burs (round burs are out of the question) and left as shallow half-round depressions are unsatisfactory. Flat walls and sharp angles give far better retention, and are more dependable in carrying the inlay to its exact place.

These cases presuppose only one proximal cavity in each tooth so treated. Where there are both mesial and distal cavities, the

problem was solved long ago by inserting inlays in cavities prepared in a similar manner as for three-quarter crowns, as far as the proximal portions are concerned. The connecting of the two cavities may be made by means of an incisal groove, or in case of thin teeth by grinding off a portion of the lingual surface. These methods have given such good satisfaction in cavities of this type, that they seem all that is needed.

In addition to these preparations which have been described, there are a few modifications of the older styles which sometimes work to advantage in these thin upper incisors. The so-called Johnson preparation, which is practically the same as one described by Black under class four for gold foil restorations, has given many

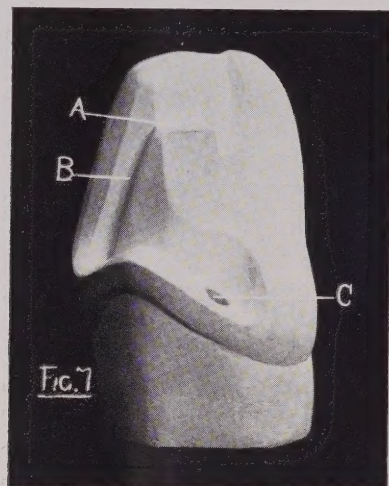


gold inlay workers much satisfaction. Only slight modifications are necessary to make them quite satisfactory where the teeth are large and thick enough to get in the required grooves at the incisal, and perhaps a pin near the lingual end of the gingival wall. Provided always that the patient is old enough to have teeth whose pulps are not too near the incisal edge, this type of tooth lends itself very well to this form of cavity.

In the special forms being advocated, this latter contingency does not need to be taken into account to the same extent, since deep cutting is not necessary and they can all be inserted at any age where it would be safe to insert any type of gold filling, and

this perhaps gives them a much wider application than just for thin small teeth as previously stated. In many cases as well, where the teeth are large and fairly thick, but the patient young, the operator will find that he can insert these special inlays with a greater degree of safety and confidence than if he were compelled to do the deeper cutting called for in the older forms.

Figure 7 is such a modification, but instead of the groove at the incisal, retention is obtained at this point by making a ledge (A) and notch in the same manner as at B—Fig. 4. The proximal groove B—Fig. 7, is the same as at A Fig. 5, which prevents lingual displacement, and a pin is put in at C, which is very efficient at



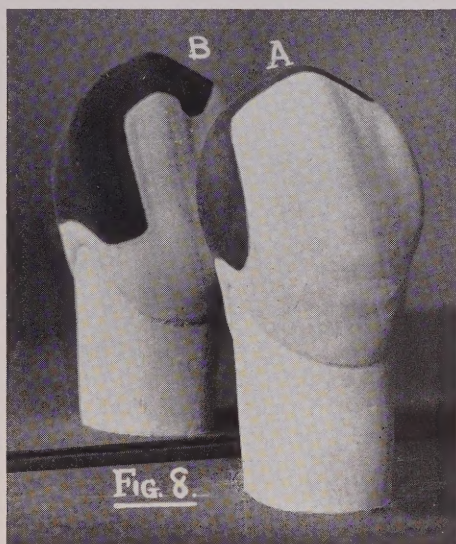
this point in resisting movement in the labial direction, due to the force of the bite.

Should the proximal cavity be so deep that a good groove cannot be made on that surface, the remainder of that wall may be ground flat with a safe-side disk; and after removal of the remaining carious dentine, the hollowed out portion may be filled level with cement and another pin inserted in the gingival wall near the labio-gingival angle. This pin will serve to supplement a partial proximal groove, and the two will together act as very efficient retention; especially if such partial groove can be made near the incisal, as is often the case.

Where such a groove cannot be safely placed on this surface, the operator will need to think out some other form of preparation,

as there would be little else in this type to prevent lingual displacement except cement, and cement should never be depended on to that extent.

In all these cavities, the sole thought has been to have the inlays mechanically retained against those forces most likely to dislodge them, the cement simply acting as a sealing medium, and in a measure only aiding the mechanical retention, or preventing displacement in any unexpected direction, such as that in which the wax pattern was removed. All inlays in fact should be capable of displacement only in a direction opposite to any force likely to be exerted during mastication. This has been accomplished in all



the preparations shown. One exception may seem obvious at first sight, in Fig. 3, where the force of the bite would be lingually on the incisal at B. It will be remembered, however, that the gold is very thin at this location, and therefore very little area exposed upon which force can be exerted in that direction. In addition the labio-gingival step, resists displacement in the lingual direction. Inasmuch as the labial portion must rise in order to allow the inlay to tip backward, this cannot take place so long as the labial step holds, and in practice it seems quite capable of doing so.

In all cases where teeth are plainly visible, an effort should be made to show the minimum of gold consistent with strength.

This applies to the incisal edge of all anterior teeth and especially to the cuspids since it has been so frequently ignored when filling these teeth. Only a narrow strip of tooth substance should in most cases be ground from the labial of the incisal edge so that when finished only a narrow, parallel strip of gold conforming to the original or desired form of the incisal edge will be visible (see Fig. 8, A).

This visibility can be further reduced—even to the vanishing point in many cases—by judicious finishing, so as to leave the surface of the gold rounded at this edge, and its shape will thus be such as to avoid reflecting light in a forward direction.

By grinding the cuspids in this way instead of the too frequent manner of cutting them straight across, the restoration is not only more artistic, but the shape of this part of the cavity lends itself more readily to retention due to the hook-shaped incisal step thus obtained (Fig. 8, B).

Many modifications of these preparations may be made; but enough have been suggested that each operator may work them out for himself, once the principles of these have been thoroughly mastered.

WAX PATTERNS

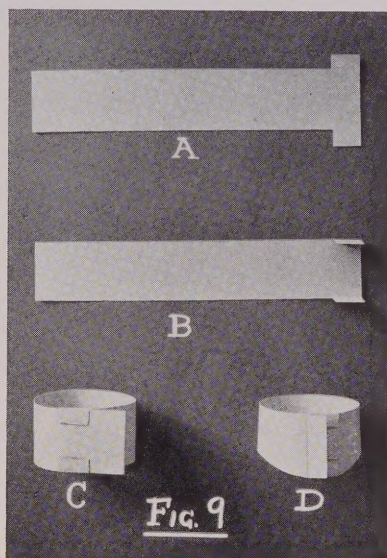
In making patterns for inlays such as these, a matrix should always be used, and for this purpose each operator may choose what in his hands has given him the most satisfaction. However, the one chosen should be capable of easy removal, so as to cause the least disturbance of the wax. The one known as the T band matrix is an old favourite with many, and in addition to its being easily made, answers all the requirements quite admirably.

The first step in making this band is to cut from a thin sheet of copper or nickel-silver, a T shaped piece as illustrated in Fig. 9, A. This should be sufficiently long to reach well around the tooth and leave considerable surplus at the free end. The short flanges are then bent at right angles to the strip (B), the other end is bent around and passed between the flanges, which are then bent down, forming an adjustable “keeper” C.

The matrix is then passed over the tooth, fitted rather loosely and the free end bent back as in D, making a lock that can be easily altered to suit the requirements. Any undesirable surplus of the free end may be clipped off, the gingival margin festooned and the matrix is ready.

The softening of the wax can be done best in water, at a temperature of from 135° to 140° F. After removing the matrix from the tooth, the wax is placed inside the band and both are immersed in the hot water until the wax is sufficiently soft to flow very readily under gentle pressure. Matrix and wax are then pressed on the tooth and in the cavity by steady pressure, which should be maintained until the wax has cooled well below the flowing point.

The matrix is removed by unlocking the joint, cutting away the loose ends, and drawing the remainder of the matrix out in a



horizontal direction, so as not to disturb the wax as might be done if pulled out in the direction of the long axis of the tooth.

The wax is then trimmed approximately to the desired form, and whilst in the tooth, a hot instrument is passed successively through every portion of the pattern for the purpose of relieving the elastic tension due to the wax having been put in under pressure. This always seems an advantage, but especially so in the particular investing process which is to be described later. In this, warm investments are used and unless this confined elasticity is removed by this or some other means such as described by Van Horn in the Dental Cosmos, March, 1919, it will be released by the heat during the investing process, and there will be an inevitable warping of

the pattern, which will spoil the fit of the inlay. For delicate patterns such as these, this hot instrument method seems to give best results and is very easily accomplished. The trimming is then completed and the pattern removed.

REMOVAL OF THE PATTERN

In the case of Fig. 1 this is accomplished by exerting gentle pressure with a cold blunt instrument or the ball of the finger upon the labial region near the gums, until the wax is seen to move slightly. A small explorer can then be inserted in the wax at this point, and the pattern gently worked out; taking into account the peculiar directions of its movements (see drawing 1a). It will require careful handling at this stage, but if the preparation has been accurately done there need be no special difficulty experienced in this regard.

In Fig. 3 the removal is accomplished in the same manner except that the preparation being reversed, the direction of force should be applied in the labial direction, and the pressure exerted on the lingual portion near the gums.

Should there be any difficulty in the wax bending or breaking at the labial step during the removal from this preparation, a bit of gold wire can be formed into a staple and its ends heated and inserted as shown in Fig. 3a. This will also be of advantage during the investing process as it will prevent bending of the wax at this point.

Figure 5 will present no special difficulties either in making or removing the pattern, since both will be accomplished in much the same way as in the case of three-quarter crowns. The same may be said of the rest of the preparations shown.

It is however, essential that a careful technique be followed in all inlay work; and of all the different steps, the making of the pattern is far from being of the least importance. The matrix should therefore, always be used in such cases, and may only be omitted when the walls surround the cavity as in class 5 cavities, in such a way that the soft wax will have no chance of flowing out of the cavity whilst under pressure. Neither should release of the elastic tension before the pattern is removed be overlooked, and in all cases this step is very essential to good results.

When pins are necessary, a piece of gold and platinum wire, just large enough to closely fit the hole may be heated and passed through the wax into its place in the tooth, after the pattern has received its final trimming. The hot pin will fuse firmly into the

wax and will therefore hold its position better than when it is inserted in advance of the wax. The free end of the pin should protrude sufficiently to allow of its being firmly held by the investment (Fig. 7a).

THE INVESTING PROCESS

The writer is a firm believer in the importance of using warm investments of a definite temperature; the necessity for which was suggested by the writings of Van Horn, who began contributing articles on this subject to the *Dental Cosmos* about twenty years ago.

Before describing the writer's modification of the process, let us consider a few phenomena taking place in the casting process which in the hands of many have militated against the best results in inlay making. These difficulties have arisen chiefly from three causes, (1) the contraction of the inlay wax when removed from the mouth and allowed to cool; (2) the shrinkage of the investing material during the burning out process; and (3) the contraction of the gold after it has been cast.

These things taken singly may seem of little importance; but added together they furnish a discrepancy that will produce nothing but very imperfectly fitting inlays.

The different waxes on the market may vary in their coefficients of expansion, but it will suffice for the present to take one that is quite generally used—namely Taggart's green wax. By careful measurements it has been found that its linear coefficient of expansion is approximately .0004286. This will vary slightly, depending on the method of manipulation of the wax, but will be sufficiently near the average to represent very closely any careful technique with this particular wax.

If wax ceases to flow, as some writers claim, at 110° F, and is then invested using water for the mix which has been left standing in a room at 70° F, it will be found that the investment will register a temperature five or six degrees lower. This is due to the evaporation of the water which always lowers the temperature of any substance from which the evaporation takes place. This will mean a total falling of temperature in the wax of say 45° F, which in turn will cause considerable contraction of the wax. If water is used directly from the tap, especially in winter, it will often be much lower than room temperature, and there will be a correspondingly greater contraction of the wax. But for the present it will answer our purpose to presuppose that it was used at 65° F.

By carefully measuring, under these circumstances, a piece of Taggart's wax 100mm. long, it will be found that it shows a contraction of 1.07 mm. A proportionate contraction in a pattern 5 mm. long, which may be taken to represent the proximal portion of an inlay, will then be one twentieth of 1.07 or .0535 mm.

Taggart's investment, mixed according to directions, burned out at a temperature of 600° F, and allowed to cool to 70°, will according to the same reasoning show a contraction at this portion of the mould of .0175 mm. There is always an inevitable contraction of the gold, and taking pure gold for our experiment, 5 mm. according to its coefficient of linear expansion (.00001453) would contract .0755 mm.

We will now do some book-keeping and make a balance sheet showing what happens in casting under these circumstances.

CARELESS TECHNIQUE

	Dr.	Cr.
5 mm of Wax contracts from 110° F to 65° F.....	.0535 mm.	
5 mm. of investment contracts from 600° F to 70° F....	.0175 mm.	
5 mm. of gold contracts from 1940° F to 70° F.....	.0755 mm.	
Total.....	.1465 mm.	Nil.

This leaves nothing in the credit column, and the debit represents a space between the inlay and the gingival margin equal to the thickness of about three sheets of "foolscap", which is quite a considerable space. But as bad as this looks, it is but an example of the technique all too frequently followed by the type of dentist who boasts that his results are "good enough". A tenth of a millimeter is quite a perceptible space; but here we have a gap fifty per cent. wider, and the operator who is satisfied with this is not aiming at a very high mark.

These discrepancies however, can be increased considerably by greater faults in technique, such as releasing the pressure too soon whilst forcing the soft wax into the cavity; using more water than the directions call for in the investment; allowing the graphite and other heavier ingredients to settle and using only the upper and thinner part of the mix; and burning out the wax at a very much higher temperature. And all these things are not uncommonly done.

A MORE CAREFUL TECHNIQUE

	Dr.	Cr.
5 mm. of wax carefully manipulated and fitted at 90° F gains in length when heated to 115° F		.03 mm.
5 mm. of investment heated to 500° F gains in length...		.015 mm.
5 mm. of gold contracts.....	.0755	
	.0755	.045
	.045	
Total Contraction.....	.0305	

The discrepancy is still three one hundredths of a millimeter; but even that is better than nearly five times that amount as was the result of the first example. This according to experiments can be entirely eliminated by casting at a temperature of 900° F; but it has been the writer's experience that such castings are very rough, and it is better to compromise by using a heat of 700° and making a thicker mix of investment, taking thirty-three per cent. by weight of water instead of about thirty-seven as used in the regular formula.

It has been found too that if the wax is burned out at a temperature of 500° F and the casting made without allowing the investment to cool, and the rest of the technique followed as stated in the last paragraph, that very satisfactory results are obtained. Whilst in theory even yet the inlays should not quite reach the gingival margin, in practice it actually does so. This at least seems to be the result in the case of simple cavities, and in most M.O. or D.O. types. But in M.O.D. cavities, even a slight shrinkage will cause a binding on the two opposing axial walls, and there will be that inevitable shortage at the gingival. Every effort should therefore be made in the latter case to produce a full-sized duplicate of a perfectly fitting wax pattern, and this seems to be facilitated by a higher temperature of investment at time of casting as indicated above.

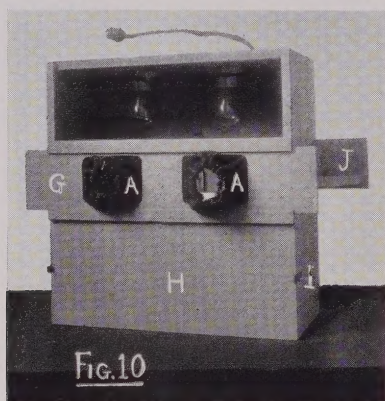
Someone has made the remark that cool investments produce the better looking inlays; but the hot investments the better fitting. That seems to represent the facts quite well in the experience of many inlay workers.

EXPANDING THE WAX MODEL

This has been accomplished by various methods; one of the simplest of which is by mixing the investment with water at about 130° F This when tried did not yield the results promised, since it was found by placing a thermometer into the investment, that before it had set sufficiently to prevent its following up the con-

traction of the wax, the investment had cooled to very nearly room temperature. It did however, prove to produce a slight lengthening of the pattern, and therefore a proportionate improvement in the size of the mould.

This was not good enough, so various methods were experimented with, including Van Horn's of heating all the materials used either in, or surrounded by water at approximately 115° F. This seemed a great step forward; but due to the necessity of mixing the investment in contact with the cooler air of the room, there was a considerable falling of the mercury, the extent of which depended so much on the time consumed in this operation, that no two results were the same. The return of the invested inlay to the hot water-surrounded oven as directed (by the inventor) seemed to raise the



temperature very slowly, and did not seem to reach the desired maximum before the setting process had advanced too far.

The inlays resulting were however a distinct improvement as a rule. But the uncertainty was not sufficiently eliminated, and further experiments were made with this in view.

Figure 10 shows a cabinet constructed for the purpose of heating all the materials and instruments used in the investing process. Its dimensions are:—height 22 inches, width 20 inches, thickness 10 inches, glass window 19" x 6". A shelf is placed 6 inches below the glass and a sliding door (G) made to fill the gap.

Two holes 5" x 3 $\frac{3}{4}$ " are made in this sliding door for the passage of the hands and thick cloth sleeves (A) are tacked to the board surrounding the holes. Elastics are run into the hems at the free

ends to make them fit closely on the wrists, thus preventing the escape of heat whilst the hands are inside the cabinet. Wooden doors covering these holes may be used for this purpose at all other times. A removable door (H), held on by two springs (I), closes the remainder of the front.

The shelf (J) seen at the right, is a revolving one, in the form of a quarter circle, hinged at the back and with two doors—one closing the opening from the inside when revolved outward, and the other closing it from the outside when turned inward.

The sides, top and bottom of the cabinet, are made of three-quarter inch boards. The back and front, of quarter inch three-ply white wood. The construction and dimensions may of course be varied to suit the fancy of each individual; but as described it seems to be of convenient size and arrangement.

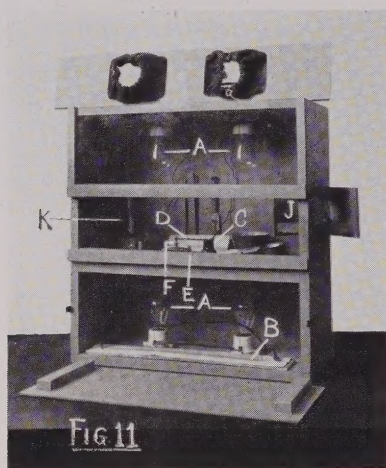
It was first heated by four 8 candle power carbon lights (A), Fig. 11. These proved to give very nearly the desired temperature, which was usually maintained fairly well for some time after rising to approximately 120° F. This gave very good satisfaction, and can be recommended to anyone wishing to make a trial of the outfit. Their chief drawback was the slowness in heating, and it also required considerable watching due to uncertainties of the current. A heating unit (B) was therefore installed consisting of a coil of 17 feet of 30 gauge "Cromel" wire. This warmed the cabinet more rapidly, and the temperature was controlled by the home-made thermostat (C), the active part of which (D) was made by riveting together at close intervals, a strip of copper, uppermost 21 gauge, and one of hard vulcanite, 15 gauge. This was connected between the two upper carbon lights, which left one to burn continuously, and the other to act as a "pilot"; its going out showing when the heat had reached its maximum. Any desired temperature can be attained by turning the screw (E), which either increases or decreases the tension between the platinum points (F), according to whether the screw is turned up or down.

About an inch below the glass window is placed a shelf, having an inch space all around the edge for the entrance of heat from below. These spaces are covered with wire netting to prevent articles falling through whilst working. On or surrounding this shelf will be seen all the instruments and materials used in the investing process. A thermometer (K) is standing in a dish of water. This is essential as the temperature of the water determines that of the investment, which as stated above will always be lower than the surrounding air. In this case, due to the higher temperature, the

evaporation will be more rapid, and the air will be about ten degrees higher after the water has been fully warmed.

In using the cabinet the lights should be turned on at least half an hour before investing; but in case of lack of time, heating the water and the investment will hasten the warming up process. Giving plenty of time however, will prove the better plan, and an hour or more, when convenient, will insure greater accuracy.

The wax pattern, after removal from the mouth, should be washed with soap and water and a camel-hair brush to remove any mucous or other accumulations that might resist the proper coating with the investment, a sprue-former inserted and placed on the



revolving shelf (J), in a spare crucible-former (or a hole in the shelf) outside the cabinet, to remain there until the investment is ready.

A small amount of investment may first be mixed outside the cabinet, and the inlay painted. This precaution is taken so as to obviate the necessity of keeping the pattern in the hot interior while the main mix is being made and painted on. Otherwise the wax would soften and be easily distorted. This will not take place if painted outside and invested as soon as it is brought into the cabinet.

The investment may now be mixed inside the cabinet, and the ring filled; the wax pattern brought in by swinging inward the hinged shelf (J), placed in the crucible-former, and at once inserted into the upper end of the ring by a "two steps forward and one

backward" motion, for the purpose of excluding bubbles. As soon as it has been completely immersed, the whole may be dropped to place, leaving the crucible-former covering the upper end of the ring. There seem to be less bubbles formed on the pattern when this method is used, than when the ring is placed on top of the crucible former, and the investment poured into the open upper end. Another advantage in placing the crucible-former on top, is the fact that both ends being closed, evaporation is checked, and there is consequently not so rapid a falling in temperature.

A rather slow setting investment should be used in this method, as a quick setting one will not give sufficient time on account of the heat accelerating the process. Taggart's seems to work out about right, but doubtless others may answer the purpose equally well.

It seems wise just here to mention that it is advisable to mix only as much investment as will be needed; because by so doing the ring will be filled with ingredients in the right proportions. If more is mixed, it is very difficult to prevent the heavier particles settling and the portion used will not contain the right proportions of the ingredients of the powder: and there will be too much water. The amount of powder necessary can be determined by filling the ring heaping full, and then placing it in the balance which should be done long enough before the mixing to allow of its being sufficiently heated.

The wax pattern should be invested soon after it is taken from the mouth, since it is known that wax will shrink when left over night, even at the same temperature. This tendency however, seems to have been exaggerated by some, for when wax *seems* to have had time to assume room temperature, it in reality contains considerable latent heat, and by inserting a thermometer into a piece of wax, it will be seen that the heat passes away very slowly, and if the wax is fairly large, it will remain above room temperature for several hours. This accounts in a large measure for the shrinkage which apparently takes place from other causes than through loss of heat.

WAX ELIMINATION

Several methods of wax elimination were tried, but it was finally decided that the following very simple technique gave as good results as any. This is done in two stages: (1) the drying process; (2) the burning out process.

THE DRYING PROCESS

About twenty minutes after the pouring of the investment, the crucible-former and sprue-former can be removed, and the ring placed on the open top of an ordinary small electric stove for half an hour.

No effort is made to get rid of the wax during this stage. In fact the ring is placed in such a position that the wax will not run out, for it is believed that a certain amount of carbon remaining in the investment, improves the quality of the investment and makes a smoother casting. Much of this carbon is ultimately burned out at the higher casting temperature, but in any case the results seem better when the drying is done in this way.

BURNING OUT PROCESS

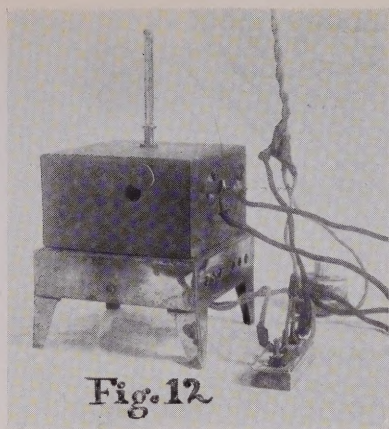
A hood (Fig. 12), made of two thicknesses of sheet iron, between which is a fairly thick layer of asbestos paper, is placed over the stove and the investment. In about eight minutes the ring is removed and tested for smoke by holding it up before the light with a pair of tongs, and waving it back and forth. If smoke appears, it should be returned to the covered stove and tested from time to time until no more shows.

The investment should then be immediately transferred to the casting machine (Fig. 13), under which a bunsen burned or gasoline torch is placed, the temperature run up to 500° F, the gold melted in a separate crucible to a glowing white heat with acetylene blow-pipe, and carried to place by centrifugal force.

Melting the gold will usually run the heat up in the investment about fifty degrees, so this must be taken into account when calculating the desired temperature.

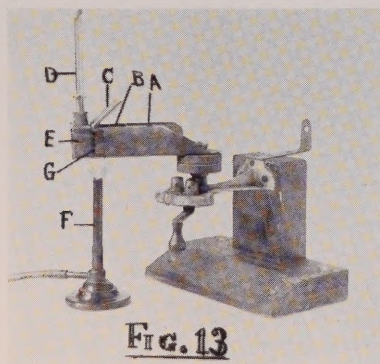
It may now be explained why it was not considered essential to eliminate the wax at any very definite temperature. It was found by experimenting that so long as the burning out process was done at a temperature high enough to eliminate the wax, and kept anywhere below that required for the investment at the time of casting, that any such variations which might occur between these two extremes, did not seem to make any perceptible difference in the results.

This might seem like a very empirical manner of attempting to get results that should only be attained by exact scientific means; but since a higher temperature is going to be reached at the time of casting, no harm can be done by using any degree of heat for the burning out process that does not exceed the desired casting



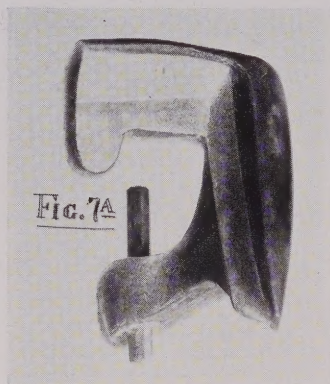
temperature. It is found by using a thermometer in the investment under the hood, that in half an hour the temperature ran up to about 450° F, therefore leaving considerable margin of safety. When too long continued however, it might do damage by burning out certain ingredients in the investment; so it is well to determine by actual tests in each case, just how long it will take to get the desired degree of elimination, and not keep up this part of the process longer than necessary to eliminate the smoke.

In reference to the kinds of gold used in the casting process, this should be determined entirely by the requirements of the case. For small inlays such as those described for the lower incisors,



pure gold is preferred, due to its constancy and its greater ease of manipulation in case of the necessity for burnishing.

To overcome the chief objection which can be raised against pure gold—that of softness—after finishing, the incisal portion or any part likely to be subjected to attrition, may be slightly ground off, the inlay imbedded in a little crown and bridge investment, and 18 K. solder flowed over the part needing protection. Where much stress is likely to be exerted, one of the harder casting golds may be used.



Realizing that this matter will fall chiefly into the hands of men of experience in inlay working, and knowledge of all the technical procedures mentioned, it has not been thought necessary to go into any great amount of detail; especially in cases where the road has been travelled so frequently before. Only in such instances as it was found advisable for the better understanding of the more unusual procedures, has any attempt been made to elaborate the instructions. If the judgment of the writer has proved to be at fault in this particular, perhaps some future occasion will afford an opportunity of rectifying the mistakes.

THE CANADIAN DENTAL RESEARCH FOUNDATION

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All subscriptions are forwarded by the Secretary to the National Trust Company, Trustees, the interest only being used in support of research work in the several Dental Colleges of Canada.

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ULTRA-VIOLET RAYS

Their Application in the Practice
of Dentistry

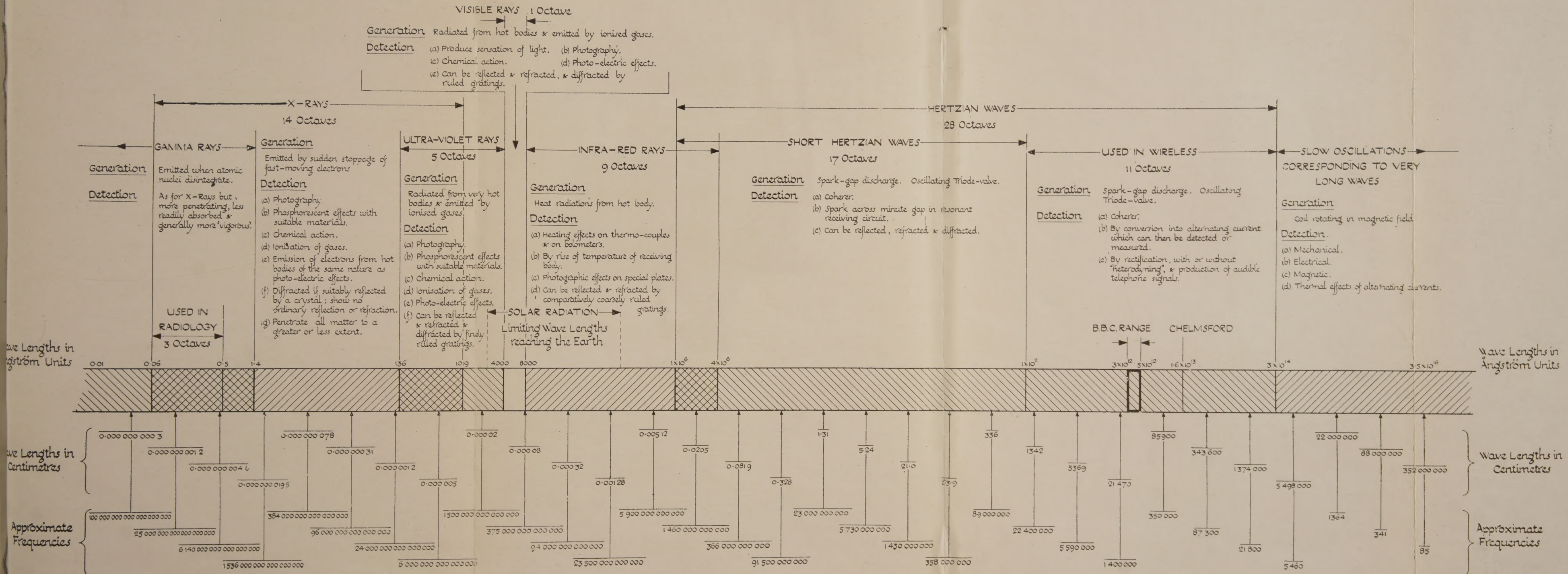
ROBERT J. READE, M.A., M.D., C.M., D.D.S.
TORONTO, CANADA

Bulletin Number Thirteen

Issued by
The Canadian Dental Research Foundation
1929

RANGE OF ELECTROMAGNETIC WAVES

62 Octaves Uniform Velocity of 30,000,000,000 centimetres per second.



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HISTORY

IT may readily be supposed that in the early existence of animal life, both man and beast, by basking in the sun, instinctively made use of solar radiation for the sense of well-being it produced.

In the natural course of events history would show that the human race existed some considerable time before a conscious study was made of the relationship that existed between solar radiation and the life, health, and growth of animals and plants.

Records bear witness that the Greeks of old knew of the healing powers of the sun's rays. That the Romans were fully alert to the advantages to be derived from basking in the sun is evidenced in their architecture, by their building solaria in connection with their dwellings.

In the first century of our era Celsus and Galen advocated the employment of the sun's rays in treating certain diseases. From the first to the eighteenth century medical literature has preserved records of the uses made by the profession in adopting the healing properties of the sun for the purpose of alleviating certain maladies. It is interesting to note that in the eighteenth century a distinction was made between the sun's visible rays, and those rays beyond the red rays, that is to say the rays outside the visible spectrum. Thomas Finneus made use of a lens to concentrate the sun's rays for the purpose of cauterizing. That is he used the heat producing rays—the infra-reds. A few years later Walter Harris used for medical purposes ground or powdered clam shells which had been exposed to the sun's action for a long time. He found that by administering this powder in certain cases (probably tetany) that beneficial results followed. Doubtless these were maladies due to a lack of calcium in the blood. A little later Schale, in the course of his experiments, learned that the rays at the extreme end of the violet spectrum exhibited a chemical property by their action of darkening silver nitrate.

In the beginning of the nineteenth century more interest in the use of sun treatment was aroused in the medical profession owing to the benefits received by patients. Toward the middle of the century a sun clinic was opened in Austria, at Vildes, for the purpose of treating diseases, as well as restoring the sense of the general well-being of the body. Later, in 1902, Dr. O. Bernhard of St. Moritz, Switzerland, obtained encouraging results in treating suppurating wounds by using solar radiations. The treatment of tuberculosis by exposing patients to the action of the sun's rays was receiving greater consideration and approval on account of the happy results obtained. This led to the establishment of more clinics for the out-door treatment of this disease with sunshine. Many investigators were now working scientifically on the spectrum of the sun's rays, and it was Charcot who first enunciated the finding that the rays beyond the violet region of the

spectrum were essentially chemical in character. He drew attention to the fact that the light produced by an electric arc, if passed through a plate of uranium glass, did not produce erythema* of the skin for the reason that glass absorbs the ultra-violet rays, especially the shorter ones. He also called attention to the similarity of the erythema produced by the arc light and the sun's rays. It was thought that the inflammation produced by the sun was due to the heat rays, but Widmark, of Stockholm, showed, in 1880, that the condition was due to the chemical rays of the sun. Bernhard, in 1917, points out the connection between sunlight and bone formation, attributing to seasonal conditions the appearance of rickets in a little village of Switzerland, where winter lasts nine months. He says that children born in autumn who remain indoors all winter develop rickets, while those born in the spring and who enjoy the advantages of the sun's rays escape the malady. In 1922, in Toronto, it was demonstrated that metabolic changes of the body were favourably affected by the energy of actinic rays.

And, bringing the history to the present moment, almost daily reports show the recognition of the importance that the ultra-violet rays play in the life of the world.

In London, England, in the Zoological Gardens, where the most up-to-date reptile house has just been completed, there is provision made in the infirmary for ultra-violet ray treatment of the animals.

There appeared the other day a report on children's health in Chicago with the following heading:

"Synthetic Sunshine is Beating Luminary in Building Children's Health in Chicago."

Synthetic sunshine in wholesale quantities, declared even more efficacious than the actual article, is building health and strength in hundreds of children at the Spaulding School for Crippled Children. An apparatus, said to be the world's largest mercury-quartz lamp and the only one of its kind, has been constructed there, and administers treatment at the rate of 150 children an hour.

After tests and experiments for two weeks the equipment was demonstrated recently to a group of scientific and medical experts by Dr. Benjamin Goldberg, director of the municipal tuberculosis sanitarium, and designer of the machine.

The chief feature of the contrivance is an automatically moving platform that carries the children through at a rate designed to give each small group the prescribed dosage of ultra-violet rays. Six large mercury-quartz lamps are ranged, three on each side, giving radiation to every part of the body.

Each of the small patients wears a minimum of clothing for his daily sunshine bath and colored goggles to protect his eyes from the glare of the lamps.

* See description of different degrees of erythema under section on technique of application.

The following is a report from Guy's Hospital, London, England, respecting the nurses on night duty:

Artificial Sunlight for Night Workers.

Nurses on night duty, and there are hundreds of them, as can be imagined, have been found to suffer sadly through lack of sunlight. Even in the best weather they can secure little, spending as they do the major part of their time off-duty in rest. The general rule is for them to take a short constitutional after coming off duty, then retiring until time to start their work again. Guy's Hospital has devised a most successful means of repairing the lack of the sun's rays. Artificial sunlight baths are taken, three times a week, by the nurses at this hospital, with most beneficial results. Other hospitals, it is expected, will follow suit, and perhaps night workers in different professions will seek the treatment.

The vital importance of sun baths in preventing and curing disease, particularly in infants and growing children, and the accompanying need of avoiding dangerous burning, are stressed in a health bulletin prepared by Dr. C. J. O. Hastings, Toronto's Medical Officer of Health.

He points out that the medical properties of ultra-violet rays of sunlight are practically eliminated by ordinary window glass, clothing, fog, smoke, dust, and by the cold of the northern hemisphere, and that children and persons living in the north, especially in cities, are robbed of the valuable elements of sunlight.

"Sunlight is a most important factor in the lives of growing children," he writes, "and treatment with sun baths if the weather will permit, should begin when they are about one month old. The normal growth of bone is primarily dependent on the food a child eats, food containing an ample supply of calcium and phosphorus."

At the American Medical Association to be held in Oregon of the present July, 1929, a report on the relation of ultra-violet rays and rickets will be made. Figures held to indicate that lack of sunshine is the direct cause of rickets in children and that under-nourishment is not a contributing cause have been compiled by the United States Children's Bureau.

It is a substantiation of the theory that the sun bath alone will give immunity from the juvenile bone disease.

SOLAR RAYS

An intelligent application of "Light Therapy" requires some acquaintance with the constitution of the solar spectrum, and the significance of the different rays composing the spectrum. Matter is composed of atoms, and the atom is built up of electric units. The simplest is the hydrogen atom made up of two electric particles. Those particles are of two kinds, a positive and a negative, respectively named the proton and electron. The only difference in chemical elements is in the number and arrangement of the electric particles. Just as in the solar system the planets revolve around the sun, so do the electric particles move, the electron around the proton which is more massive. Further the atoms radiate energy just as the heavenly bodies radiate, and it is by their radiation that we know of

their existence. The ether is a something that pervades space, and it is by the vibration or tremor in the ether, excited by a corresponding movement in the protons or electrons, that different wave lengths are caused. This consideration will give some idea of what is meant by radiation, and different wave lengths. Electrons are given off by bodies when struck with the ultra-violet light.

Only a small portion of the sun's rays that reach the earth are visible—hence the expression the “Visible Spectrum.” So, strictly speaking, the term “Light Waves” should be applied to that portion of the sun's rays that so affect the optic nerve as to produce the sensation of color.

The spectrum of the sun's rays admits of three general divisions:

1. The visible spectrum—red, orange, green, blue, indigo, and violet.
2. The infra-reds, those rays beyond the red.
3. The ultra-violet, those rays beyond the violet.

The detection of the invisible rays below the reds, the infra-reds, can, among other ways (consult fig. 1), be effected by means of a bolometer which, being placed on the spectrum just below the reds, shows an increase of temperature. The infra-reds are the heat producing rays and the wireless waves.

A photographic plate placed on the spectrum beyond the violet rays demonstrates the presence of chemical rays by a darkening of the silver salts.

The qualities of the various waves are due to the difference of the length and frequency of the ether waves. Some of the waves are so short that a nomenclature has been devised to describe them, as in like manner in dealing with great astronomical measurements the distances are so great that they are measured in “Light Years.”*

There are three ways in use to express short wave lengths, and they are all based on sub-division of the meter, namely the micron, the millimicron and the Angstrom Unit.

The symbol for the micron unit is the Greek letter μ , and its length is one thousandth ($1/1,000$) of a millimeter. That is to say the millimeter is divided in a thousand parts.

The Millimicron is denoted by $m\mu$ which means that the millimeter is divided into a million parts, therefore the millimicron is one millionth ($1/1,000,000$) of a millimeter.

The third method is the use of the Angstrom Unit, so named after the Swedish physicist who invented it. The Angstrom Unit, written A.U. or $\text{\AA}$, is one ten millionth ($1/10,000,000$) of a millimeter. In long measure the Angstrom Unit is one two hundred and fifty-four millionth ($1/254,000,000$) of an inch.

On account of the decimal system employed it is quite easy to convert the A.U. into terms of the $m\mu$ or vice-versa by dividing or multiplying by ten.

* A Light Year. Light travels at the rate of 186,000 miles per second—so a Light Year would be $186,000 \times 60 \times 60 \times 24 \times 365$, which equals 5,865,696,000,000 miles.

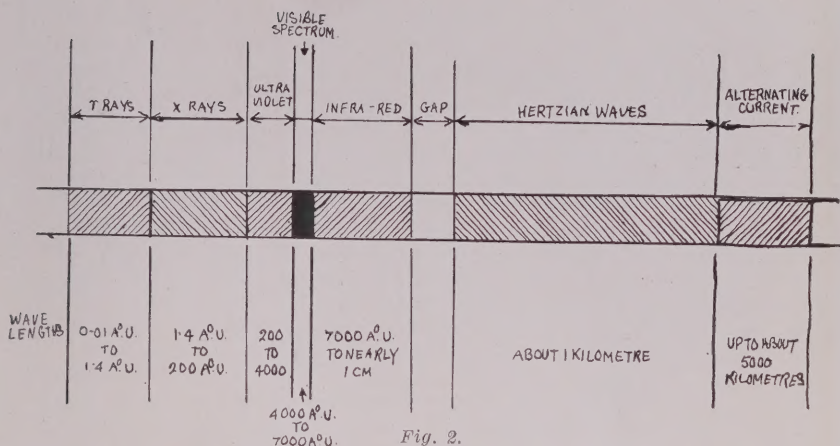


Fig. 2.

Figure 2 gives a working scheme, for our purpose, of a division of the sun's spectrum. In the central portion is the region of the visible rays—red, orange, green, blue, indigo and violet. The wave lengths range from the red 7,000 to the violet 4,000 A.U. Beyond the visible spectrum, adjacent to and below the reds, is the region of the infra-reds; it is the field of the heat-producing rays; then comes an uncharted section of which not a great deal is known at the present time, but which is receiving close scientific study; beyond this uncharted section are the long Hertzian waves of wireless energy. The infra-reds then are those rays longer than 7,000 A.U. Beyond the violet of the visible spectrum there is the ultra-violet field which includes all waves less than 4,000 A.U. The ultra-violet field is shown to be sub-divided. The region immediately beyond and next to the violet is the Actinic or Chemical portion of the spectrum commonly indicated by the assumption of the name of the whole region, that is ultra-violet. It is this part of the electro-magnetic spectrum with which we are now concerned, and which includes wave lengths of 3,900 to 200 A.U.

Then come the X-rays and radium rays. The shortest waves known are the gamma rays of radium which range in length from 1.4 to 0.01 A.U.

There is a variation in the amount of solar rays that reach the surface of the earth. This variation is due to the atmosphere which exists between the earth and the sun. As this atmosphere varies in depth and composition so does the proportion of the sun's energy that reaches the earth vary. It is estimated that only sixty per cent. of the sun's rays reach the earth even in a clear atmosphere. This loss to the earth of solar energy is mainly due to the absorption of the rays by the ozone, water-vapor, and oxygen of the surrounding atmosphere.

This envelope has the property of absorbing, in addition to other rays, some of the shorter ultra-violet waves, so that the shortest rays that reach the earth are 2,900 A.U. That is to say the ultra-violet rays of the sun

that reach the earth vary from 3,900 A.U. to 2,900 A.U. It has been shown by investigators that the shorter ultra-violet rays are the most effective from a metabolic point of view, so that the ultra-violet rays ranging from 3,100 A.U. to 2,900 A.U. are the most efficient sun rays for the well-being of life. It is estimated that these rays constitute less than one per cent. of solar radiation.

An estimation of the value of the different ray-lengths is arrived at by means of the use of various glasses of known transmissibility, known as filters. These different glasses have been tested and compared with common window glass by the United States Bureau of Standards, and results set forth in scientific papers. (Consult Circular 235, January 14th, 1928.) These experiments demonstrate that wave lengths of 3,200 A.U. or more, have no protective value in the treatment of rickets,* while actinic rays of 3,100 A.U. and less have been found to have a profound effect on the disease. This means that the difference of only 100 A.U. in length is the difference between effectiveness and ineffectiveness. This fact may have a very important bearing in the further study of light therapy, and filters may play an important role in treating various ailments.

For those pursuing the subject of heliotherapy, it is interesting to consider the significance of the experiment of Burge which proved that the longest waves capable of coagulating the white of eggs was 3,000 A.U. The effect of different wave lengths on the condition called rickets points to the value of a further analysis of the rays employed in heliotherapy to ascertain if eliminating or combining certain ray lengths will produce results not yet known.

One of the notable characteristics of the ultra-violet ray is its feeble power of penetration. This peculiarity of the rays requires a consideration of the conditions which govern the amount of ultra-violet rays which are accessible to us.

The localities in which moisture, smoke, and dust are present, such as large manufacturing centres, are lacking in the normal quantity of ultra-violet rays because these particular rays are intercepted by absorption before they reach the earth. Other localities, where the atmosphere is dry and free from such impurities as smoke and dust, receive the normal amount of ultra-violet rays sent forth by the sun, and are consequently more suited for such uses as require these special waves.

In addition to the consideration of the peculiarities of the locality, the time of the year has much to do with the quantity and quality (that is the length) of the ultra-violet rays that pass through the atmosphere. In the winter the sun is so low that the rays come obliquely and so must pass through a greater depth of the atmospheric envelope to reach the earth, and in consequence more of the ultra-violet rays are absorbed.

Another very important circumstance that relates to the time of exposure to the sun's rays, is the time of day. Here again, in the early morning and late afternoon, the sun's rays shine obliquely and must pass through a greater depth of atmosphere with the consequent absorption of the ultra-

* For a description of rickets see page 15.

violet rays. So the mid-day is the time when the earth's surface receives the rays in greater abundance.

It is often stated that sunlight at the top of Mount Blanc is richer in ultra-violet rays than in the sunlight of lower altitudes. Thorne Baker has shown that at an altitude of 5,000 meters the sunlight contains no shorter rays than 2,900 A.U. The ozone atmosphere which surrounds the earth absorbs ultra-violet rays shorter than 2,900 A.U. If this is so how could it be supposed that any reasonable altitude that a human could reach would contain shorter rays than the oxygen atmosphere will allow to pass through it. So the statement that altitude affects the proportion of ultra-violet rays available for humans must be reconsidered.

Another factor to keep in mind is that ordinary window glass cuts off the short ultra-violet rays. So that an individual sitting in a sun-room, closed in with ordinary glass, although apparently bathed in a flood of the sun's rays, is quite cut off from the essential ultra-violet rays.

The following findings of the Bureau of Standards, Washington, or the ultra-violet transmission of various new glasses and window glass substitutes as compared with that of common window glass, are not only interesting but of vital importance, because of the manufacture of special ultra-violet transmitting glass for solaria, sun-rooms, schools, homes, office buildings, animal houses, and greenhouses. The ultra-violet rays that reach the earth from the sun vary in length from 3,900 A.U. to 2,900 A.U. The most essential rays for biological purposes are 3,100 A.U. and less. Ordinary window glass eliminates ultra-violet rays shorter than 3,200 A.U. From these findings it is evident that sun treatments given for their actinic rays when given behind ordinary window glass must prove a failure. It is pitiful to think of the mistakes made in the past when patients spent hours in the sun-room expecting to receive the benefits of sunshine when those special rays longed for were cut off by the intervening glass.

With the manufacture of various substitutes for window glass the transmission of the sun's ultra-violet rays is to some extent effected, but it must be clearly understood that there is a difference of transmissibility among the various substitutes, and, furthermore, the percentage of transmission varies when the substitute is new and when it is old.

PER CENT. TRANSMISSION OF VARIOUS GLASSES AT 302 MM.,
WHEN NEW

Trade Name	Number of Samples Tested.	Average Thickness.	Average Per Cent. Transmission
			At 302 m μ
Fused Quartz	1	4.7 mm.	92
Corex	4	2.8	89
Helioglass	15	2.3	56
Vitaglass	15	2.5	44
Cel-o-glass	5	.1 (about)	30
Quartz-lite	16	1.9	0.5
Common Window Glass.	14	3.3	0.0

When aged, that is in about six weeks or more of exposure to ultra-violet radiation, the following change takes place in glass substitutes. When the glass is aged it is said to be solarized, and then it becomes constant.

PER CENT. TRANSMISSION OF VARIOUS GLASSES AT 312 $m\mu$,
WHEN OLD

Trade Name.	Average Per Cent. Transmission	
	At 302 $m\mu$.	
Fused Quartz (no change)	92	per cent.
*Corex (no appreciable change)	89	"
Helioglass (marked)	30	"
Vitaglass (marked)	25	"
Cel-o-glass (marked)	5 to 10	"
Quartz-lite (no appreciable change)	0.5	"
Common Window Glass	0.0	"

Another condition that requires attention is the relation that clothing bears to the transmission of these vital rays. Such covering on the body interferes with access to the body of these special health-giving rays. A sufficient surface of the body must be nude so that there will be no medium of adsorption to prevent the ultra-violet rays reaching the skin.

Hess had made experiments to test the penetrability of clothing to actinic rays. He selected thin material of a white cotton dress, cotton and wool sacks. These were interposed between the rays to be examined and the subject, and it was found that the rays afforded protection against rickets. These materials were white. Black material of the same texture was then used and no protection against rickets was afforded.

Other Sources of Ultra-violet Rays Than Solar Radiation.

It will be noted that the previous section is under the caption of "Solar Rays." There are, however, other sources of actinic rays. In the development of light for clinical purposes, methods have been evolved to produce a spectrum closely resembling the sun's spectrum, or simulating the actinic spectrum, or corresponding to the infra-red region of the spectrum. All artificial light emits ultra-violet energy—but in some cases the energy is very slight. There are three principle sources for securing actinic energy for clinical purposes, namely, the Sun, the Carbon-Arc Lamp, and the Quartz-Mercury Vapour Arc Lamp.

Professor Finsen, of Copenhagen, invented a lamp, known as the "Finsen Lamp," in order to obtain a maximum of ultra-violet rays with a minimum of infra-reds. One of the first lamps to be used clinically was his Carbon-Arc Lamp. It was due to his discoveries that work was continued that led to the development of the lamps in use at the present time. The Carbon-Arc Lamps may vary in the spectrum they produce by modifying the composition of the carbons by coring or impregnating them with metals such as aluminum, tungsten, iron, and chrome-steel. Other Carbon-Arc

* Exposure to a quartz-mercury arc causes a very marked decrease in the transmission, but no appreciable change on exposure to solar radiation.

lamps, besides the Finsen, are "Siemen's Aural Lamp," the "Wohlite Lamp," the "Solar Arc Lamp of Battle Creek," and "Sunzone Carbon-Arc Lamp," and others. Particular information regarding construction and merits of the different lamps can be obtained by consulting the bibliography.

The Quartz-Mercury Vapour Arc Lamp, consists of a quartz vacuum tube and liquid mercury. When the circuit is closed the mercury is vapourized giving off an intense light rich in actinic rays. There are two types of Quartz-Mercury Vacuum Burners. One type (the Hanovia) has the two electrodes of mercury. Another type (the Cooper-Hewitt), the cathode is of mercury and the anode of tungsten. The quartz tube will not emit rays shorter than 1,850 A.U. Compare this with the length of the ultra-violet wave that reaches the earth from the sun. The spectrum from the quartz-vacuum tube does not consist solely of ultra-violet rays, but radiates a portion of the visible section and the infra-red; but the infra-reds are not so strong from the quartz-vacuum as from some other sources of ultra-violet energy. With the water-cooled Kromayer Lamp, the ultra-violet wave intensity to visible wave intensity, is much greater than it is either with the Carbon-Arc, or with the sunlight. There are two kinds of Quartz-Mercury Vacuum Lamps. One, which is air cooled and used for general radiations, as, for example, the Hanovia and Victor Lamp; the other is the water-cooled lamp used for local applications, as the Kromayer and Victor Quartz Lamp. The lamp for local applications is constructed so that it can be fitted with tubes of quartz of different sizes and shapes for use in the oral cavity.



Fig. 3.

Fig. 3.—The Alpine Lamp for general radiation of the body.

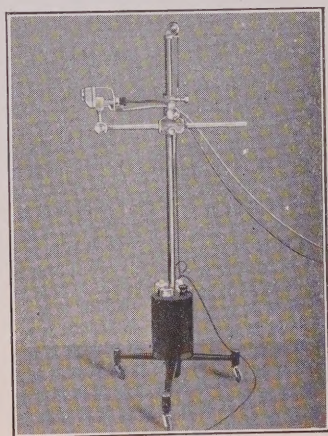


Fig. 4.

Fig. 4.—The Kromayer Lamp for local applications.

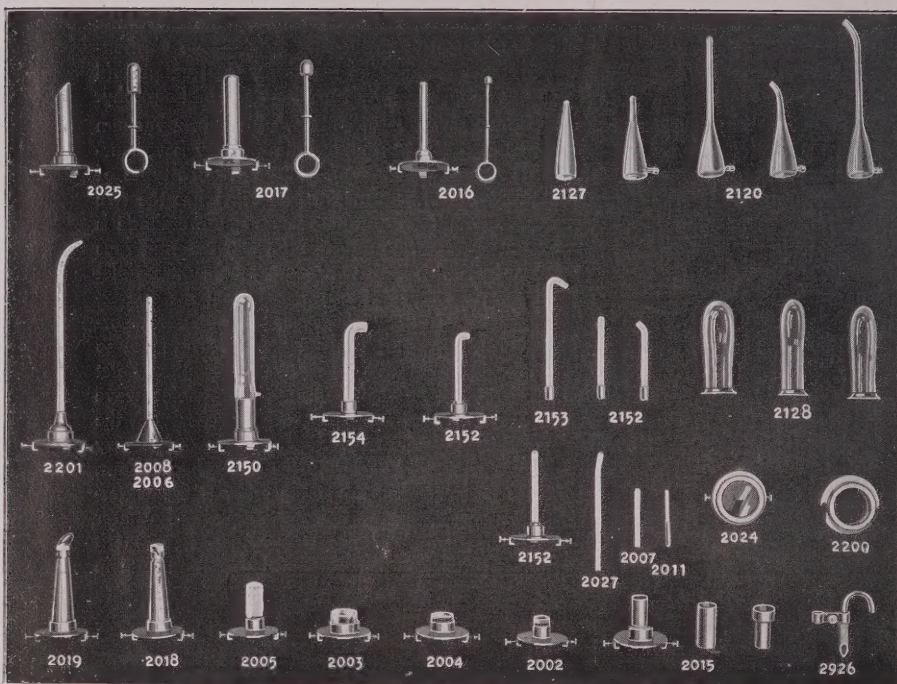


Fig. 5.

Applicators for local treatments.

THE USE OF APPLICATORS

- | | |
|---|--|
| 2002—Small round lens | } Used in all compression where it is desired to force the blood out of the tissues and obtain deep penetration as in deep infections. |
| 2003—Large square lens | |
| 2004—Medium round lens | |
| 2152—Sampson pyorrhea rods.—The popular type of pyorrhea applicators. | |
| 2153—Used in hay fever. | |
| 2005—Long round lens.—Used in Vincent's angina where compression is necessary as in hemorrhoids. | |
| 2007—Quartz rod $2\frac{3}{4}$ " long.—Used principally in the outer ear, eczema, and furunculosis, etc., about 6 mm. diam. | |
| 2008—Long quartz rod $6\frac{3}{4}$ " long.—Used in empyema, tubercular kidney, gonorrhea, about 6 mm. diam. | |
| 2011—Weaver applicator, small rod about 3 mm. diam.—Used in children's ears and small sinuses. | |
| 2015—Shapre localizer.—Three open cylinders for confining the rays to a small area, as in boils, etc. | |
| 2016—Sinus applicator.—Used in tubercular sinuses. | |
| 2018—Pharyngeal applicator.—Used in tonsillar conditions. | |
| 2154 and 2019—Used in tubercular laryngitis. | |
| 2027—Nasal applicator.—Used in ozena, hypertrophied turbinates, etc. | |

RICKETS

The most definite knowledge of the action of ultra-violet rays on the metabolic processes of the body has been gained through a study of its effects in relation to the conditions due to a disease called rickets. An understanding of the pathological conditions observed in this disease is necessary to an intelligent understanding of the results we expect to attain in dentistry by the use of actinic energy. The similarity of the pathological conditions found in rickets to many deficiency dental conditions encountered will gradually be observed as the pathological anatomy of rickets is studied.

Rickets is a disease of infancy, characterized by an impaired nutrition of the whole body, and lack of development of the bone tissue. There is a deficient deposition of calcium salts in the bone, and in the intercellular cartilage of the epiphyses. It rarely begins before the sixth month, and usually in the first or second years. The disease begins insidiously and shows symptoms before the child begins to walk, about the time of dentition, which process is much disturbed and retarded. The teeth erupt late, and decay early. In the morbid anatomy the changes most noticeable are in the ends of the long bones and the ribs. The ossification is more irregular, and the bones more spongy and vascular than normal. The parieto-occipital and the parieto-frontal fontanelles remain patent, due to a lack of ossification. There is also the appearance of the "rickety rosary," a beading of the ribs at their junction with the cartilage. The primary lesion seems to be in the periosteum, marrow, and cartilage. It is believed that rickets is due to a disturbed nutrition by the arterial blood in which there is a marked diminution of calcareous salts. There seems to be a causal relation between rickets and broncho-pneumonia, asthma and epilepsy, that is a reduction in the defensive power of the blood.

Rickets is associated with a marked lowering of general resistance to infection in children. The greatest mortality among them is due to broncho-pneumonia and similar conditions.

In the adult also the ultra-violet rays are in some way related to metabolic processes which increase the resistance of the individual to bacterial invasion. After exposure to the rays there is found to be a marked increase in the number of platelets in the blood. The blood platelets are considered to be in some way related to the resistance of the body against infection. The resistance of the whole population to ward off disease is reduced in winter months, and this is apparently due to the lack of exposure to the beneficial effects of sunshine, especially the shorter ultra-violet rays. This lack of resistance is shown by the greater mortality during the late winter months. Tisdall says, "If a knowledge of these facts can be disseminated throughout our communities, and applied by the people, particularly during the late winter and spring months, it will result in a marked reduction in the incidence of disease and also will be the means of saving thousands of lives."

For an account of the theories regarding the etiology of rickets, the reader is referred to an article by Tisdall in the *Canadian Medical Association Journal*, December, 1922.

In rickets the concentration of inorganic phosphorus in serum is low. As the salts of the bone consist chiefly of calcium phosphate, it is likely that calcium and phosphorus in the blood plays an important part in bone formation. The calcium content in the blood of a normal healthy individual is remarkably constant, and slightly higher in children than in adults. There is no demonstrable amount of calcium in the red blood-cells. The average amount of calcium in the serum is 10.8 Mg. per 100 cc. The average amount of inorganic phosphorus in children from 4 to 22 months is 5.4 Mg., and the average in adults is 2.1 Mg. per 100 cc. In the blood of the rachetic the amount of calcium is normal or only slightly reduced, while on the other hand inorganic phosphorus is reduced to an extreme degree. Also it is to be noted that during recovery the phosphorus content increases to normal. So far as these findings are concerned they would point towards the conclusion that the lack of bone formation is not due to a lack of calcium, but rather to a deficiency of phosphorus content of the blood. It is observed by Tisdall that "physiological conditions such as diet, exercise, etc., exert little, if any, influence on the calcium of the serum."

The action of light on the organism is based on clinical observations and is, therefore, empirical. The physiological process is still obscure. Vitamins are considered potent agencies in promoting the growth and maintaining the normal health equilibrium. Vitamins are substances contained in various foods; they act like drugs on specific tissues.

For example: Vitamin A is a fat-soluble abundant in cod liver oil and many vegetable oils. Its primary source is green leaves and sea-weeds. It seems to have to do with the utilization of the fats of the body. A deficiency of this vitamin causes an atrophy of the mucous membrane of the intestines, and thus opening a way to infection from the intestines.

Vitamin B is a water-soluble found in cereals, eggs, yeast and lemons. It is considered an anti-neuretic, being antagonistic to certain forms of nervous degeneration.

Vitamin C is abundant in green vegetables and fresh fruits. It protects against scurvy and is termed anti-scorbutic.

Vitamin D is allied to fat-soluble Vitamin A, and has a similar distribution. It is named anti-rachetic, one of its functions being to promote the proper calcification of bone.

The Medical Research Committee of Great Britain published a report on rickets in which it says: "In spite of a most varied and extensive research we have practically no knowledge of the nature or causation of this widespread malady, or of the factors which determine its onset." There are two divergent theories, each of which enjoys the approval of clinicians at different times, namely, the dietetic and hygienic. Mellanby claims that the lack of a vitamin fat-soluble is the potent cause of rickets. Yet it must be remembered that rickets is more frequent among the children in large cities than in the rural districts. Another consideration is that cases of rickets increase during the winter and early spring, and rapidly disappear in the summer. This calls for an enquiry into the seasonal variation of rickets. Hess and Unger report: "In the course of our experience in a large child-caring institution rickets has been found to

occur with every food, without exception. Cases have developed when the dietary contained a large quota of milk, and therefore was rich in fat; when fat and fat-soluble vitamin were lacking in the diet; when milk was raw or pasteurized. It has been noted on a diet of fluid milk, dry milk, condensed milk, protein milk and human milk. On every one of these dietaries some babies have developed rickets, whereas others have remained perfectly normal in this respect."

Clinical evidence has shown that cases that develop rickets when fed on diet of pasture dry milk, malt soup, condensed milk and breast milk, when treated with ultra-violet rays showed an increase in the percentage of haemoglobin and red blood cells in every instance; also the X-ray showed an increase in the deposition of salts at the epiphyseal ends of the ulnar and radius; and this in the most unpropitious months of February and March. At present there seems to be no means of knowing the *modus operandi* of this deposition of salts, whether it is through direct action, or whether it is due to some intermediate factor. The effect seems to be systemic rather than local.

Raczynski performed the following experiment to show the chemical effect of solar rays on the inorganic salts of the body. Two puppies of the one litter and suckled by the mother were used. One was kept in darkness, and the other in sunshine. At the end of six weeks they were killed. When the bodies were analyzed it was found that the one subjected to the sun's rays showed over fifty per cent. more calcium and twenty-five per cent. more phosphorus than the one deprived of the sun's rays. The effect of light seems to afford some explanation of the fact that rickets is more prevalent in large cities, where children are more deprived of the sun in winter than in the summer time.

In writing of sun and artificial light treatment Leonard Hill says: "To make good for our dark winter climate and indoor life, we want to use arc baths just as we use water baths, and getting the skin in a healthy, active state, keep up resistance to disease."

THE TEETH

About the 7th week of intrauterine life, the beginning of the teeth germ is first observed. From the 7th week to the 17th week modification in development in the temporary teeth, and the first permanent molar is under way. There is the development of the ameloblasts for the enamel, and the osteoblasts for the dentine, with the deposition of lime salts. About the 25th week of foetal life calcification of the first permanent molar begins. Calcification of the temporary teeth begins about the 17th week of foetal life and is completed twenty-two weeks after birth. Calcification of the permanent teeth begins about the 25th week of foetal life and is completed about the 20th year after birth. At the same time the jaws, and the process surrounding the roots of the teeth, is in process of formation. These facts have important relationships to the results looked for in the biological action of the ultra-violet rays when applied for in their control of rickets.

CALCIFICATION AND DECALCIFICATION OF THE TEETH.

FIG. 1.

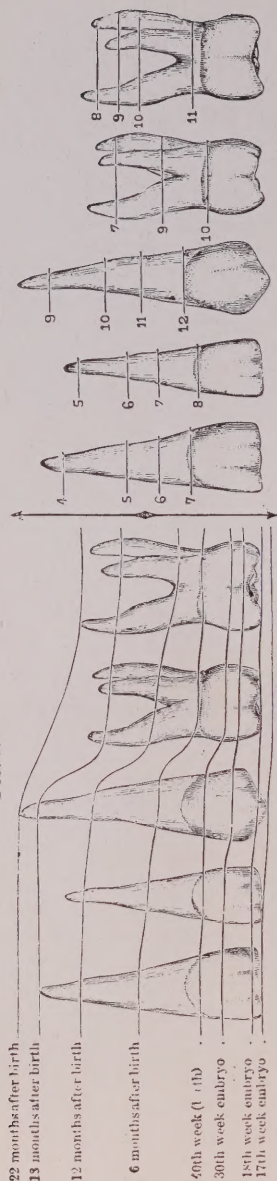
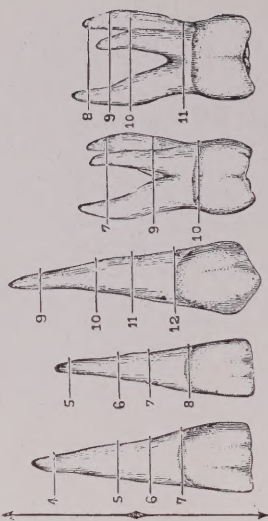


FIG. 3.

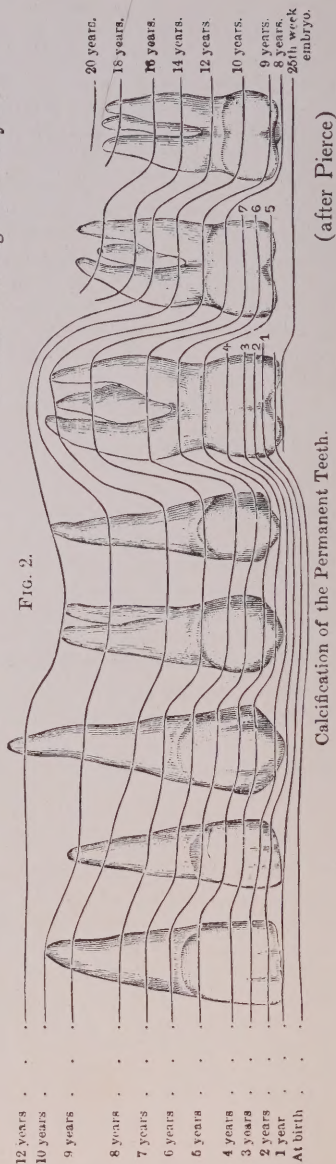


Calcification of the Deciduous Teeth.

Decalcification of the Deciduous Teeth.

The numbers on Fig. 3 indicate years.

FIG. 2.



Calcification of the Permanent Teeth.

(after Pierce)

It has been shown that the application of the actinic rays results in the prevention of rickets, and the building up of healthy bone tissue. So should the same treatment result in the development of normal teeth with their supporting bone structure. This use of ultra-violet rays would naturally result in the development of such tooth and bone structure as would tend to eliminate that almost universal and dreaded disease periodontoclasia. Such degrees of mal-occlusions and other causes that would break down the periodontium in poorly formed tissue might have little or no effect in cases of strong development. This treatment would be preventive dentistry in the building up of healthy structures that would resist in a great measure the onslaughts of bacterial invasion. From the foregoing data of the periods of formation of the teeth and their calcification it will be gathered that the body must be kept in a state of normalcy, so that during the process of bone formation the tissues will receive proper pabulum from the time of conception until the period is past when rickets makes its appearance. The effect achieved will not only produce a resistant periodontium, but the tooth itself will be more resistant to decay because the islands of calcification of the enamel will coalesce and a perfect enamel covering result.

This treatment, being preventive, only partly covers the problem of dental disease. The consideration remains of those cases that have not received the preventive treatment, but present with the periodontium in various stages of disintegration.

PERIODONTOCLASIA

There are different degrees of periodontoclasia, beginning with a simple gingivitis to the absorption of the alveolar process to such an extent that the tooth becomes movable, and finally falls out owing to lack of support of the surrounding tissues.

Before the application of the actinic ray treatment it should be understood that every mechanical irritant must be removed, as calcareous deposits, irritating crowns and fillings, ill-fitting bands, badly designed and constructed artificial dentures, and traumatic-occlusions.

In a case of simple gingivitis the analgesic property of the ultra-violet ray soothes the nerve endings in the irritated tissues, and so hastens the return of normal circulation with the color of the gingiva changed from an inflammatory red to a normal pink.

In his studies on the "Treatment of the Periodontal Pocket" Dr. Box dwells at some length on the method of taking advantage of the organization of the blood clot to obliterate the pocket. The pocket is lined on the one side with connective tissue which is covered by an invagination of the mucous epithelium; on the other side is the cementum, encrusted with lime salts. The mucous epithelium and the lime salts must be removed, and the pocket irrigated with a normal saline solution. Filling the pocket with drugs will interfere with the vitality of the cells lining the pocket, and also with the absorption of the ultra-violet rays. With the pocket suitably treated, a blood clot is formed by finally curretting the soft tissue

of the pocket. The clot which fills the pocket must be sealed and protected with a varnish. These details being attended to, it is now to nature one must trust for the transformation of the clot and the obliteration of the alveolar pocket, by the fixation of lime and phosphoric acid in the osteogenic tissue.

The cementum as a thin layer covers the root of the tooth from the enamel to the apex. In structure and chemical composition it resembles bone, containing sparingly lacunæ and canaliculi which characterize bone.

The lacunæ near the surface have canaliculi which radiate towards the periodontal membrane. In every respect cementum is closely allied to bone, and its development provided for in similar manner. The tooth-sac is made up of an outer and inner layer, both of which are rich in blood-vessels. These membranous walls continue to invest the roots of the teeth during their upbuilding. The outer layer of the sac remains as a permanent structure placed between the root and the alveolar walls, forming the alveolodental periosteum, while upon the surface of the inner layer osteoblasts (cementoblasts) are developed, which are speedily converted into bone or cementum. In this process the tooth-root may be compared to one of the long bones of the body, and the development of the cementum considered under the head of sub-periosteal ossification.

Dr. Box observes: "Examples of reattachment following conservative surgical treatment of the pocket have been noticed in abundance. This is not to say, however, that union is always assured when the necessary procedures appear to have been taken." The conclusion to be stressed in connection with this observation is, first, that it has been shown that the ultra-violet rays have a regenerative action on the growth of bone in the case of rickets by supplying a necessary food or stimulant; and that by a legitimate process of reasoning it might be fairly supposed that the rays would stimulate the cells to form a tissue that would be sufficiently dense to retain the tooth operated upon in a stable condition, and more successes might result.

In cases of periodontal diseases where the alveolar process has been destroyed, regeneration in some cases seems proved by the evidence of radiographs. If pathological conditions are removed and the teeth stabilized, more of these cases will likely be observed if the conditions due to the lack of normal deposition of lime salts are removed. It should be remembered that in cases of complete destruction of the fibrous connective tissue the condition is such that the most optimistic could not reasonably expect a favourable prognosis.

For a further understanding of the possible advantages of a calcium forming, and protective, and bactericidal energy in the blood, Box's "Treatment of the Periodontal Pocket," Bulletin No. 10, issued by the Canadian Dental Research Foundation, is recommended. The details of the transformation of the blood clot is considered, and how it is related to the connective tissue and fibrous tissue formation.

A splendid example of the reparative powers of the periodontal connective tissue and its ability to form new cement substance under suitable conditions is to be seen in a case where, through trauma, a fracture of the

dentine has occurred. Following proliferation and extension of pericemental connective tissue cells, which are cement forming, into the fissure formed by the break of continuity in the outer dentine, there is deposited on the fissure walls a formless ground substance. This cement-matrix presents here and there enclosed cement-corpuscles, and later, with deposition of calcium throughout, it becomes hard, like bone or cementum.

It will now be perceived why the effect of ultra-violet rays on rickets was discussed. In part it was to show how the process of bone building was related to the calcification required to obliterate pyorrhea pockets. The principle of fortifying the body with the required energy is the same in both cases.

ORTHODONTIA

It might be said that if the environment of intrauterine life were normal, orthodontic services would not be required. It is just because the foundation on which the teeth are built is weak and ill-constructed that the skill of the orthodontist is so valuable to humanity. The moulding and development of the maxilla and mandible with the building up of the alveolar process for the support of the teeth are dependent largely upon the nutritive conditions that surround the foetus. If a study be made of Cryer's dissections of the head it will at once become evident that the function and structure of the jaws and teeth has much to do with the development of the nasal fossae, and the sinuses. This condition the skilled orthodontist has in view when he is engaged in securing a normal occlusion.

The promotion of the growth of normal jaws and dental structure is just a part of what has been described when treating of rickets. The same treatment that will promote the growth of normal bone will produce properly developed dental conditions. It has been shown that such favourable results in the bone framework of the body have been secured by the action of the ultra-violet rays for the prevention of rickets.

But when this early treatment has been omitted, with such a result that abnormal conditions prevail that require the orthodontist, the treatment very often resolves itself into an effort to expand the dental arches in the effort to secure a normal condition of the size of the nasal passages and sinuses to produce a condition favourable to normal breathing, and a proper occlusion of the teeth for purposes of mastication. To obtain these conditions it may be necessary to move the teeth in many directions. These movements result in an absorption of bone tissue in one direction, and a space left in the other direction, which space must be filled with a deposition of new bone, so that the tooth may be firmly maintained in its new place.

The alveolar process and periodontal membrane are rich in their vascular supply, being perforated by minute openings for the transmission of nutrient vessels. In the periodontal membrane are various kinds of cells. There are fibroblasts to form fibres; there are osteoblasts to form bone; and there are cementoblasts to form cementum.

One of the difficulties the orthodontist has to contend with is the problem of the retention of the teeth in their new positions until nature has

formed new bone around the roots of the teeth to secure them firmly. In healthy children this process takes place fairly rapidly. But in the case of a weak child with a frail bony structure the problem of securing stability is a very serious one, sometimes an impossible one.

As the studies in the case of rickets have shown, this disease of lack of bone formation can be overcome by the action of ultra-violet rays. There seems no reason to doubt that such a course of treatment by the orthodontist would hasten the deposition of lime salts and secure a stronger support for the teeth in a shorter time, and so lessen the period for wearing retention bands. In the cases of debilitated children the ultra-violet ray treatment may mean all the difference between success and failure.

PROSTHODONTIA

Dr. W. E. Cummer spoke to the writer of the great value that would accrue to the patient if some method could be discovered whereby the absorption of the jaw bone, due to extraction of teeth, could in some measure be controlled. This control of tissue would give the prosthodontist a better foundation on which to construct his appliance; it would also afford the patient a much more satisfying prosthetic service. The same principle that applies to the regeneration of the blood clot in the pyorrhea pocket holds good in cases of extraction. When a tooth is moved from its socket in a case of ordinary extraction, a blood clot should be encouraged, so that it fills the socket and the clot is protected with a film of varnish so that it will not be dislodged. Every means should be taken to allow for the organization of the clot by the general and local application of the ultra-violet ray, which has been shown to be a particularly efficacious agent for this particular kind of metabolism. This treatment would materially overcome that condition in which the teeth adjacent to the extraction are losing their alveolar support. The germicidal action of the actinic ray, which will be considered later, should be taken advantage of in cases of extraction by inserting into the socket, before allowing the blood clot to form, a suitable quartz rod to irradiate the tissues with bactericidal rays.

BACTERICIDAL EFFECT OF THE ULTRA-VIOLET RAYS

The practising dentist will at once perceive the importance of the bactericidal action of the blood on the outcome of a number of operations. The periodontist, the exodontist, the prosthodontist, and the orthodontist are in a great measure dependent upon this property of the blood for the ultimate success of their operations. In the extraction of a pulp from a tooth, in the removal of the apex of a root, the success of the operation will largely be governed by the bactericidal action of the blood. This quality will reside in normal blood, or, if lacking in this respect, it may in ordinary conditions be rendered germicidal by the action of actinic rays. Eidinowe publishes accounts of experiments made by him to show that in cases where the bactericidal power of the blood is low the irradiation of the skin with the ultra-violet rays will raise that power by a constant improvement from sixty per cent. to a level of ninety-five per cent. This

change was brought about after two months' treatment. The method of irradiation was to produce a slight erythema of the skin. He also observed that too long an exposure to the rays will lower the bactericidal action of the blood. Too long an exposure is avoidable by causing only a slight erythema. It is also stated that "during menstruation the haemobactericidal power of the blood is in some cases found to be lowered, irradiation appears to make this worse, and therefore light treatment should be avoided during this period."

Many bacteria and pathogenic organisms are rapidly destroyed when subjected to the ultra-violet rays. This action can also be obtained in the presence of a thin film of blood.

Most of the constituents of the living cells are colourless so they do not absorb rays of wave lengths of visible light. In a substance the part of the beam absorbed sets in vibration the molecules, if any of the vibration periods of the rays coincide with the vibration of the atoms. The result may be a chemical or physical change in the molecules.

Many constituents of cells absorb the ultra-violet rays, which have a powerful effect on living tissue. The actinic rays produce degeneration of the epidermal cells, and there follows an absorption of the products. If the initial energy has short enough wave lengths to produce vibrations in the atoms, it is paralleled with activation of the electrons. If the result of the activation is to eject the electron from the atom, the result is ionization of the molecule; if the electron is displaced to an outer orbit, the atom is activated. In either case it results in altered chemical reactions. A bacterium is a unicellular organism, and thus similar to other tissue cells of the body, and so the statement that ultra-violet rays are destructive to tissue cells holds good in the case of bacteria.

DENTAL CARIES

Dental Caries may be due to poor tooth structure, and also to faulty formation of the tooth and its supporting structure—such are prenatal influences. Under the section dealing with teeth and their development, a mode of treatment was discussed that would tend to bring about certain conditions in the nourishment of the ovum that tooth structure would be of such a kind as could resist the ordinary exciting causes of decay. The present section deals with the exciting causes of decay apart from any consideration of tooth texture. A detailed account of the history of the different theories advanced as to the exciting cause of dental caries can be found elsewhere. It is sufficient for our purpose to state that it is agreed that an acid condition causes the decalcification of the tooth. The cause that produces the acid and the kind of acid found has been discussed in a voluminous number of papers.

Burchard and Inglis in their work on Dental Pathology treating of Dental Caries, write: "This bodily condition (referring to general health) is seemingly the key to any change which can occur in saliva, or mucous, or oral phagocytosis, to one of which must be attributed any possible systemic effect upon caries bacteria, which can aid or inhibit their growth or localization." Although it is not yet clearly proved, there is a strong

suspicion, in the minds of some, that the condition of acidosis expresses itself in the acidity of the saliva, which itself may cause decalcification of the teeth, or promote a condition favourable to bacteria that can dissolve the lime salts of the teeth.

Arterial blood is slightly alkaline; if this alkalinity is lowered below a certain point the condition becomes one of acidosis; if the alkalinity is increased, the condition is known as alkalosis. Acidosis is the result of incomplete fat metabolism owing to deficiency of carbohydrate.

Dr. G. V. Black's theory of Dental Caries is that a plaque or covering is formed to protect micro-organisms and maintain them in position on the enamel of the tooth, so that when they develop lactic acid it would not be diluted and washed away. It was this lactic acid that dissolved the enamel. In seeking the cause of dental caries he says: "Conditions of the saliva that enable micro-organisms to form these coverings, or which form them independently of the action of micro-organisms, are apparently the important objects of research." A difference in the composition of the saliva, perhaps due to the salts it contains, may influence the action of the micro-organisms and render it more rapid in some cases than in others. The relation of the conditions of the saliva to dental caries has not yet been determined, and so it is difficult at the present time to say what role the ultra-violet rays would play in the control of caries. This at least could be advanced, that the general health of the body would tend towards a normal condition of the saliva.

A theory of the cause of dental caries by Bodecker will be found in the Dental Cosmos, June, 1929. The theory is based on the fact that there is a system of channels in both the dentine and enamel, and that these channels are permeable from within and without. These channels are filled with blood plasma. This tooth plasma comes to the surface of the tooth, and normally being sufficiently alkaline, neutralizes the lactic acid that may lodge on the surface of the tooth. This dental lymph, being derived from the blood, will vary in its alkalinity as the blood varies in this respect. On the treating of rickets it has been shown how the blood does vary under different conditions with respect to its percentage of lime salts and phosphorus. Now if Bodecker's theory can be shown as related to dental caries, then the ultra-violet ray treatment, which controls the conditions of alkalinity of the blood, would be very efficient in the control of dental caries.

There are cases that present in which there is taking place a solution of the enamel at the cervical portion of the tooth manifesting itself by that white chalky appearance indicative of acid formation. These cases are distressing. Unlooked-for good results have been obtained by using the quartz applicator on the gums. The only explanation that has suggested itself is that there was some reaction on the glands of the gums which altered their biologic action and changed the acid secretion to a normal alkaline one.

ANALGESIC PROPERTIES

The ultra-violet ray has analgesic properties which it exerts on the tissue to which it is applied at the same time as it has its chemical effect.

It is a soothing and pleasing adjunct to prophylactic treatment when applied at the end of the operation. The nerve terminals of tissues which have been irritated during the instrumental procedure are acted upon by the rays in such a manner that the irritation is reduced so that the inflammation subsides, and a sense of comfort is experienced.

In cases of extraction after the application of the rays for any bactericidal action that may be required, an analgesic action follows that is very soothing to the patient.

As for the effects of the ultra-violet rays upon pus pockets and root abscesses, it is only reasonable results that should be expected. If there is a pus pocket at the root of the tooth it could hardly be hoped that the application of the rays to the gums would eliminate the necessity of skilful instrumentation and stabilization. But these conditions being attended to, the actinic rays will have their own beneficial action.

As regards an abscessed tooth, unless the conditions causing the abscess can be eliminated it is in vain to expect the ultra-violet rays to initiate an action they do not possess. Just because digitalis has the property of producing certain effects, it is not to be expected that the drug will cure a malady that requires a surgical operation.

Certain types of neuralgia and neuritis will respond in an unexpectedly favourable manner to ultra-violet ray therapy if applied with the proper technique. But there are other types of neuralgia—for example, that due to a calcerous growth in the foramen through which the nerve passes and which impinges upon the nerve, that naturally would not respond to the analgesic properties possessed by the rays.

ACTIVATION OF FOOD STUFFS BY ULTRA-VIOLET RAYS

The value of ultra-violet rays in producing in inactive foods an antirachitic virtue by means of irradiation is receiving much consideration at the present time. Experiments seem to point to the conclusion that the antirachitic factor of the food depends upon the phytosterol or cholesterol they contain. Cholesterol is the constituent in animal food from which the antirachitic vitamin is derived by irradiation; the corresponding constituent in vegetable substances is phytosterol.

Steenbock and Daniels report: "The number of food materials that can be made antirachitic by simply exposing them to the light is far from being limited. It is a property quite common to foods of both plant and animal origin. In fact, one would almost be led to assume that it is a universal characteristic, but it is not the case. We have been very successful with such diverse materials as wheat, Indian corn yeast, cream of wheat, crude casein, hominey, rolled oats, corn starch, patent wheat flour, shredded wheat biscuits, meat, milk, egg yolk, butter and liver." It has been shown by Hess and Weinstock that "activated spinach" does not lose this property of protection against rickets even when boiled for half-an-hour.

The ultra-violet rays have been demonstrated a protection against, and cure for, rickets. It is also shown that they do not deeply penetrate

the skin. The supposition then is that in some way the rays activate the skin. The skin is particularly rich in cholesterol. The question then presented itself—could the skin be irradiated so as to afford protection against rickets. Experiments have been made that show that skin activated by ultra-violet rays when fed to rats afford that protection. It appears, then, that the action of the rays on the skin so affects the cholesterol content that the blood carries away in its stream, to be distributed to the proper parts of the body, that principle that creates such biological action that affords protection against rickets. In experimenting with the activation of cholesterol it was found that an "ageing" followed the activation; when a test was made one or two weeks later the activated cholesterol, when kept in a dry state, rapidly became inert; but the active principle was found stable when suspended in oil.

There is also a time limit for the exposure of cholesterol to the ultra-violet rays. Thirty to sixty minutes' exposure at about ten inches distances produces the antirachitic property. An exposure of seventeen hours annuls the antirachitic virtue which had been established by the shorter exposure. The fact that irradiated food and actinic rays have the same effect on the condition of rickets would lead to the supposition that the active principle was a form of radiated energy.

Steenbock and Daniels give an account of an experiment that is very interesting and one that invites much thought.

Rats were fed on a diet that would cause rickets. Some were irradiated each day, and the others were not. That the environment would be the same the two classes were kept in the same cage. To the surprise of the investigators it was found that both the irradiated and non-irradiated rats all grew. The question is—why? Did the irradiated rats give off radiant energy to the non-irradiated rats? And is it radiant energy stored in the anti-rachitic food that causes normal functioning of the body cells?

Rosenheim and Webster found that the substance which undergoes change by activation is a sterol, ergosterol, which is closely allied to cholesterol. This ergosterol can be extracted from ergot a fungus on yeast and mushrooms more particularly from a fungus which develops on grain. Ergosterol has been proven to be highly antirachitic for man and beast.

Activated ergosterol is two thousand times as potent as activated cholesterol; one hundred thousand times as potent as cod liver oil. 1/20,000 mg. prevents rickets in rats.

Hess and Lewis state that one ounce of average activated ergosterol is the equivalent of four tons of cod liver oil. Their experience is that this drug never failed in rickets; that even in cases in which cod liver oil had not brought about healing, irradiated ergosterol insured a rapid cure.

TECHNIQUE OF APPLICATION

A general agreement regarding technique has not yet been evolved. To solve the problem of the best method of applying the rays each operator should keep written memoranda of his methods of treatment, together with an account of the results obtained. Careful observation is necessary, because

every patient does not respond equally to the treatment. The operator will find that the ultra-violet rays will produce a sunburn and blister exactly the same as the sun will, and with apparently equally painful and harmless results. Yet it should be realized that care ought to be exercised in the use of the rays. If reference is made to Fig. 1, it will be noticed that the x-rays and ultra-violet rays are near neighbours. Both are invisible rays, and also each has a powerful action on the human body.

There are four recognized degrees of erythema that can be caused by the actinic rays:

First Degree Erythema is very mild, and does not cause any subjective symptoms. There is a very slight flush of the skin, which is not so affected as to produce any visible exfoliation.

Second Degree Erythema is likened to a very mild sunburn. The skin is reddened, and after the reaction there is a slight granular exfoliation of the skin.

Third Degree Erythema amounts to a severe sunburn. The skin becomes very red and, as in a bad sunburn, peels off in strips.

Fourth Degree Erythema is so severe as to cause a blister.

Tables have been compiled giving both the distance of the lamp from the patient and the time required to produce the different degrees of erythema. These rules are not dependable, for there is a difference in the powers of lamps built by the same companies. There is also a difference of energy given off by a lamp when it is new and when it has been used for some time. It is also stated, but only generally true, that the skin of blondes is more readily affected by the rays than the skin of brunettes. That is to say, blondes will be burnt by an exposure to the rays that would not seriously affect a brunette. The only safe guide is to consider each case by itself. There is a very safe method to determine the susceptibility of the particular patient to the rays. This is conveniently done by baring the patient's arm and applying the rays on different areas for different lengths of time, and next day noting the various degrees of erythema produced. If a quartz applicator is to be used for local contact, as, for example, to the gum tissue, then the applicator is pressed against the arm in different localities for different lengths of time, as one-half minute, one minute, one minute and a-half, and next day results noted for guidance in calculating the time exposure for treatment. If the rays are to be applied without the use of the quartz applicator, at a distance, as, for example, to the side of the face, or for general systemic treatment to the body, then the bared arm can be covered by a paper sleeve, secured in place, to protect the arm. Before adjustment, in this sleeve on the inner aspect of the arm, several apertures about the size of a ten-cent piece are cut, so that the rays can reach the skin. After the rays have been applied for one-half minute, one of the apertures is covered. The application is continued till the second aperture has admitted the light for one minute; it is then covered. This operation is continued, and finally there are several areas which have been irradiated for different lengths of time. The results can be observed next day by noting the varying degrees of erythema produced.

If a general treatment is to be given to the exposed body, the safest advice is to go slowly, giving the first treatment at a safe distance for a short time. A treatment can be given each day, gradually increasing the time of exposure. For the first treatment let the distance of the lamp from the body be about thirty inches, and the time of the exposure two minutes each on the back and chest. It should be noted that a patient lying on the back is a few inches farther from the source of the ultra-violet rays than when exposing the back, and perhaps lying on the arms. Increase the time each day according to indications till there is a ten-minute exposure, then begin to lessen the distance. There are some operators who desire to secure a severe reaction. This is not recommended, because a pinkish flush of the epidermis produces the reaction necessary to bring about that biologic action necessary to prevent or cure rickets. The reason for this recommendation is the consideration of the results obtained by the ultra-violet ray contained in "Skyshine," as compared with direct sunshine. If an object is placed in the shade it receives only the reflected light from the sky, that is skyshine. If it is placed in the sunshine it receives both the direct rays from the sun and also the rays from the skyshine. Tisdall and Brown found that the antirachitic effect of the ultra-violet rays in skyshine was about one-half as great as in sunshine. It was also noted that the antirachitic effect of the skyshine was produced without reddening of the skin. It would seem that the reddening of the skin cannot be used as a measurement of the beneficial results of radiations. Further, too severe a reaction is likely to bring about a defensive action of the skin to the rays. After all, experience must be the guide that distinguishes a safe from an unwary operator. When the desired reaction is established the treatment may be reduced to two or one a week. One or two treatments a month during the winter time will have a tendency to establish a protective resistance to ward off colds that are so prevalent between the fall and the spring of the year. If after any one exposure too great an erythema has been produced, there should be a longer interval before the next treatment.

In order to secure the full action of the lamp in the production of the ultra-violet rays it should first be allowed to burn for five minutes. Goggles may be used to protect the eyes of the operator. Looking at the light too long causes an iritis. One should not look steadily at the ultra-violet light any more than a prudent person would gaze at the strong sunlight. Experience has proved that there is no need for the casual operator to be encumbered with goggles. But the case is different with the patient receiving a general treatment. While exposing the chest, the goggles or some protection for the eyes should be provided. Goggles seem to be unpleasant to the patient because they produce an uncomfortable sensation of heat around the eyes, and may give rise to the suggestion that other people have worn them. A gauze napkin laid across the eyes is all that is necessary, besides each patient then can have the pleasurable sensation of knowing they are using a clean napkin. Another method to protect the eyes is to drape the hood of the Alpine Lamp with a material of sufficient length to cut off the rays from the face.

After treatments have been discontinued for some time, for example, a

month or six weeks, the operator should be wary not to begin again at the distance and time exposure of the last treatment. It will be found that the defensive action of the skin to the ultra-violet rays has subsided. An initial treatment at the time and exposure of the last treatment would likely have unpleasant results as regards the degree of erythema produced.

For local application to the gums by means of the quartz applicator a greater degree of erythema may be desired so that it may act as a counter-irritant.

CONCLUSION

The conclusion to be drawn from the foregoing facts and experiments is that the oral cavity cannot be successfully treated as a separate entity. The several parts of the body form a connected whole. The tissue cells in whatever parts of the body they may be situated are subjected to and are controlled by the same general laws. For example, if the normal germicidal property of the blood is lowered, in a general way the same disastrous results will attend a like injury whether in the abdomen, or at the apex of a tooth root. Conditions that would respond to treatment in a healthy individual, *i.e.*, to say, with a normal bactericidal action of the blood, may in an unhealthy organization resist the effect of treatment.

If, when abscessed conditions prevail in the mouth, it is considered unwise to expect a favourable result in the treatment of what is called "a run-down condition," a case of general debility; it is also unwise to expect a successful termination in the treatment of mouth conditions when any diseased organ of the body is lowering the general health and vitiating the fluids which bathe the tissue cells.

The dentist must realize the direct relationship, as regards cause and effect, that exists among the different parts of the body. It is not the mouth that we are finally concerned with, but the general health of the individual as related to the conditions of the oral cavity. It is only in this way that we may hope to realize the possibilities of our profession in rendering service to mankind.

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NECROTIC GINGIVITIS

(TRENCH MOUTH)

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INTRODUCTION

NECROTIC gingivitis is still very prevalent. Its intractable nature is particularly noticed at periodic intervals when it assumes epidemic proportions. This bulletin is offered in response to the need which has been expressed by the dental profession for a treatise upon the subject. Any labour involved in its preparation will be amply repaid if it will help to call attention to some of the unsolved problems in this important subject and will serve to stimulate research along these lines.

This monograph is an embodiment of the author's views on the subject of necrotic gingivitis. Much of the information has been drawn from clinical sources and the methods of treatment herein described have been tested in practice and are believed to be clinically sound. The subject has been discussed from clinical, bacteriological, pathological and physico-chemical aspects with the thought of establishing a less empirical and a more scientific basis for diagnosis and treatment.

HAROLD KEITH BOX.

NECROTIC GINGIVITIS

DEFINITION.—Necrotic gingivitis is an infectious inflammation of the gingival tissues, exhibiting lesions characteristic as to location and nature and occurring only in mouths where teeth are present. It is characterized by a type of pseudomembrane formation—at least by a soft layer composed mainly of bacteria and necrotic tissue—and superficial ulceration. The disease frequently spreads widely and rapidly, involving other mucous membranes of the mouth, thus establishing a stomatitis as an added complication.

SYNONYMS

Trench Mouth
Trench Gums
Phagedenic Gingivitis
Acute Ulcerous Gingivitis
Acute Ulcerative Gingivitis
Ulcerative Gingivitis
Ulcerative Stomatitis
Ultero-membranous Gingivitis
Ultero-membranous Stomatitis
Vincent's Gingivitis
Vincent's Periodontitis
Vincent's Stomatitis
Vincent's Angina
Vincent's Peridental Angina
Plaut-Vincent's Stomatitis
Stomatitis Ulcerosa
Stomatitis Ultero-membranacea
Fuso-spirillary Gingivitis
Fuso-spirillary Marginal Gingivitis
Fuso-spirillary Peridental Gingivitis
Fuso-spirillary Peridental Gingivitis
Fuso-spirillary Periodontitis
Foetid Stomatitis
Putrid Stomatitis
Putrid Sore Mouth
Stomatocace

Stomacace

Acute Septic Gingivitis

Pseudomembranous Angina

Spirochætal Stomatitis

SIGNS AND SYMPTOMS

(1) Of first importance in the syndrome is the presence on the gingival margin of a destructive lesion covered by a grayish, grayish-yellow, yellowish-white or greenish-white pasty slough or pellicle which when rubbed or lifted off leaves a sensitive bleeding surface. Preceding the destruction, the area affected is as a rule red, tumefied* and very sensitive. It tends to bleed readily and sometimes profusely after the slightest injury. This, however, is soon followed by the formation of a pseudomembrane-like deposit which at this stage has a great deal of resemblance to that caused by the Klebs-Loeffer bacillus and with which it is sometimes confused. Hardgrove¹ states that in Vincent's infection of the tonsil this pseudomembrane is not so white as that found in diphtheria and is more easily removed. It must be kept in mind, however, that in the more severe forms of infection with the diphtheria bacillus, the pseudomembrane may also be yellow, gray, olive-coloured, or where hemorrhages accompany the inflammatory process, more or less black. In necrotic gingivitis, the ulcers have a well-defined margin and clinically have often been wrongly diagnosed as syphilis. The tissue-destruction in its peculiar involvement of certain portions of the gingival contour gives the tissue a characteristic eroded, "punched-out" or "dissected away" appearance. Because the ulceration is of a rapidly and widely spreading nature, the term phagedenic gingivitis was applied to it by early writers on the subject (Coplin)². Years later, Stillman and McCall³ adopted the same appellation for this disease. Through involvement of the alveolar process and

*A lesion involving the distal gingivæ of lower third molars and the soft loosely attached tissues posterior to them and resembling in some respects the early tissue changes in necrotic gingivitis is extremely common in acute lymphatic leukemia and terminal exacerbations of chronic lymphatic leukemia. This is commonly spoken of as a lesion of leukemia. The tissues present a solid, heaped-up, turgescient and nodular appearance. Sir Kenneth Goadby, K.B.E., referring to this lesion in his book "Diseases of the Gums and Oral Mucous Membrane" states that there is no necrotic ulceration of the gum edges and that from the buccal sulcus upwards, the whole gum was affected.

pericementum, a special type of simplex periodontitis⁴ is frequently established. From our present knowledge of these lesions, based on the pathological findings and in the absence of positive proof of the primary etiological factors, it is felt that the term "necrotic gingivitis" best designates this disease.

(2) Next in importance in the syndrome is the distinctive and peculiarly offensive odour. The breath becomes intensely foul, and this putrid, fetid odour once experienced is alone almost sufficiently characteristic to establish a diagnosis of necrotic gingivitis.

(3) Another symptom of major significance is the factor of sudden onset. Frequently the patient can state the date of the appearance of the main symptoms of the disease. This is particularly true in cases of epidemic type.

(4) The gingival tissues are usually very tender, and in some instances so painful as to interfere with normal mastication of food.

(5) There is an increased flow of saliva, frequently bloody from slight gingival hemorrhages, and usually of a metallic taste.

(6) Frequently there is a feeling of uneasiness and mouth discomfort evidenced at times by a wedging sensation in the interproximal spaces.

(7) Patients sometimes state that the teeth feel "wooden" or "dead" to the bite, as if the pericementum were anaesthetized.

(8) Occasionally there is swelling and pitting of the tongue.

(9) The submaxillary glands and other neck glands may be swollen.

(10) The presence of macroscopic pus is not a requisite sign.

(11) Loosening of the teeth is not characteristic but may be found in late stages of the disease.

(12) General symptoms such as malaise, increased temperature, accelerated pulse rate, pallor of the skin, mental depression, insomnia, vertigo, restlessness, nocturnal mental hyper-activity and lack of appetite are common.

(13) Gastric disturbances such as acidity, flatulence, regurgitation and occasional vomiting are also familiar symptoms.

(14) Alternating diarrhoea and constipation are not uncommon.

(15) An exanthematous eruption resembling measles is sometimes observed.

Many cases are observed in which the history gives evidence of a previous necrotic gingivitis. In these cases most of the foregoing symptoms are absent or are very much modified. The character-

istic sign is the "punched-out" appearance of the labial or lingual aspects of the interproximal gingivae. In addition, the bulk of the interproximal gingiva is also still further cupped out, creating thereby a crater-like depression the sanitation of which is impossible by care on the part of the patient. Bleeding from these areas is common, although seldom as severe as in the acute stage. It is the opinion of many periodontists that this form of subacute or chronic gingivitis bears some etiologic relation to the acute or necrotic type. Indeed some investigators consider necrotic and chronic gingivitis to be two types of oral spirochetosis, the first an acute form, and the second a chronic form.

Doubleday⁵ has stated: "On what does the suggestion that there really is such a condition as chronic fuso-spirillary infection of the gum rest? I think one may put forward as good evidence the undoubted fact that there is a clinical condition of the gum characterized by the presence of serum and blood, but little or no pus, in which these organisms are found in direct smears, and that when in the course of treatment the organisms gradually disappear the clinical signs clear up as well."

Gangrenous Stomatitis.—This disease fortunately is a comparatively rare one and is usually observed in children from two to five years of age. It begins in unusually debilitated children, and as a rule during convalescence from infectious diseases such as scarlet fever, typhoid fever, diphtheria, and as Osler has pointed out, in particular, measles. The first lesion is a small nodule, dense and sensitive, appearing on the gum or inside of the cheek. A gangrenous process follows, attended by sloughing of the involved structures. In mild cases, the primary necrosis may be limited to one of the starting points and with healing may leave the parts deformed—and disfigured if penetration of the cheek has occurred. The disease advances by a progressive necrosis and, as a rule, this process extends rapidly, perforating the cheek and involving the chin, tongue, jaws and sometimes even the ears and eyelids. The soft parts are converted into blackish-green or brownish foul-smelling masses and the bone becomes necrotic. The disease usually terminates fatally in from one to two weeks by septicemic processes.

The histo-pathology of gangrenous stomatitis will be discussed later in its relation to the histo-pathology of necrotic gingivitis.

GENERAL DESCRIPTION OF THE COURSE OF NECROTIC GINGIVITIS

All cases of necrotic gingivitis and stomatitis may be divided into two classes, viz:—

(1) Those in which the disease has been established by activation of the microorganisms through the presence in the mouth of all the necessary factors for rapid anaërobic growth.

(2) Those in which the disease has been established through contagion, *i.e.*, the communication by mediate or immediate contact with virulent microorganisms.

Close observation has revealed that in the first class a rapid multiplication of the fusiform bacillus and incidentally the spirillum takes place in certain regions through a combination of conditions which favour anaërobic growth. These regions are termed by the writer "primary incubation zones". Through extremely favourable cultural conditions in these sites, the bacteria become more virulent. Fine examples of "primary incubation zones", in the order of their importance are as follows:

(a) Gingival flaps on partly erupted lower third molars.

(b) Palatal margins of interproximal gingivae of upper centrals associated with deep gingival crevices or pre-existing periodontal pockets.

(c) Buccal gingival margins of molars in crowded contact with folds of the mucous membrane of the cheek.

(d) The tonsils: (it must not be overlooked that the tonsils frequently furnish a good example of "primary incubation zones".)

It is well known that bacteria at any point on the upward curve of growth are more liable to spread and grow under conditions somewhat less favourable for their growth. In other words they become more virulent. This has been shown for pneumococci by Bloomfield and Felty⁶ and is probably a general characteristic for all bacteria, including fusiform bacilli and Vincent's spirilla. This would account for their new colonization in relatively unfavourable sites, in which, however, due to certain depressing conditions, their multiplication is permitted. These sites have been termed by the author "secondary incubation zones". Here rapid proliferation and resulting increased virulence may again take place, thus continuing the process, with the exhibition of the characteristic

symptoms of the disease. Examples of "secondary incubation zones" are as follows:

- (a) Gingival tissues of teeth in traumatic occlusion.
- (b) Gingival tissues, having a pre-existing inflammation; calculus, rough margins of dental restorations, cervical caries extending beneath the gingival margin, mouth breathing and excessive smoking are common causes. (Here, as a rule, we are dealing with a consecutive infection, that is to say, the Vincent's infection is implanted upon an infective process already established.)
- (c) Periodontal pockets.

When the infection has been established through contagion, as in the second class, both the primary and secondary incubation zones may become the sites of the lesions. As stated previously, the virulence of the microorganisms in part determines their establishment in relatively unfavourable sites, as in the secondary incubation zones, and as Hardgrove has stated, the more virulent the microorganisms, the more likely they are to operate on a free surface. The free mucous surfaces of the gingivae, alveolar mucosa, cheeks, tongue, and floor of the mouth are obviously less favourable sites than the "secondary incubation zones", but in severe cases where the microorganisms are especially virulent, these frequently exhibit the characteristic lesions of necrotic gingivitis.

Examples of mediate contagion, *i.e.*, contagion conveyed by a person or object from the sick to the well, are found in infection from common drinking vessels, eating utensils in restaurants, trains and steamships, also from door-knobs, telephone receivers, and common towels*. Immediate or direct contagion *i.e.*, contagion from direct contact with a sick person, is well exemplified in coughing, or kissing.

In many cases, the highly acute phase of necrotic gingivitis lasts from four to seven days; in others, however, the period is much longer and may last for several weeks. With diminution of the more severe symptoms, the acute phase is followed by one of subacute or chronic infection.

In these chronic areas, both primary and secondary, containing

*Sir Frank Colyer, on his recent visit to Toronto called the author's attention to his interesting observation that necrotic gingivitis was frequently seen in hostlers.

fusiform bacilli and spirilla, conditions allowing a very slow multiplication are apparently present. With favourable cultural conditions, the microorganisms may take on a rapid growth and virulence with exacerbation of the old process. That trauma may be a factor in this exacerbation is well known to the dental practitioner. As Hirschfeld⁷ has pointed out, scaling and extraction are frequently followed, in from twenty-four to thirty-six hours, by symptoms of so-called acute Vincent's infection.

ETIOLOGY

(1) *Bacterial Factor*

The nature of the lesions was not clear until Plaut⁸, Vincent⁹ and others reported uniform bacteriological findings. In smears taken from the lesions, there is found a spindle-shaped or fusiform bacillus with which is associated as a rule a long spirillum, not unlike the spirillum of relapsing fever. Abel¹⁰ first succeeded in growing the *Bacillus fusiformis* in the laboratory. It was grown in mixed cultures with a contaminating Gram-negative coccus, and disappeared on sub-culture. Following numerous attempts of many investigators, it was finally grown in pure culture.

The relation of the two microorganisms, the bacillus and spirillum, has been the subject of much controversy. The work of Tunnicliff¹¹ favours the viewpoint that these two forms are different developmental phases of one organism. This investigator cultivated the organisms anaerobically upon slants of ascitic agar at 37.5°C. Before the fifth day, the fusiform bacilli only could be found but later the spirilla appeared. From the observation that finally the spirilla predominated, it appeared that they represented the adult form, having developed out of the bacilli.

On the other hand, these two microorganisms are regarded by other workers as two distinct species closely associated in symbiosis. Mühlens and Hartmann¹² in isolating from the same case both the spirilla and fusiform bacilli, found the colonies to be quite distinct. They were unable, further, to find evidence of the mutation of these organisms. Later the findings of Krumwiede¹³ confirmed the observations of Mühlens and Hartmann.

Hiss and Zinsser¹⁴ have given the following description of these microorganisms: "The fusiform bacilli described by Vincent, Plaut and others are from 3 to 10 micra in length and have a

thickness at the centre varying from 0.5 to 0.8 micron. From the centre they taper gradually toward the ends, ending in blunt or sharp points. The length of these bacilli may vary greatly within one and the same smear preparation. They are usually straight, sometimes slightly curved. They do not stain very easily with the weaker anilin dyes but are readily stained by Loeffler's methylene-blue, carbol fuchsin, or better by Giemsa's stain. Stained by Gram, they are usually decolorized though in this respect the writers have found them to vary. Stained preparations show a characteristic inequality in the intensity of the stain, the bacilli being more deeply stained near the end and showing a banded or striped alternation of stained and unstained areas in the central body. Their staining qualities in this respect are not unlike those of the diphtheria bacillus, and according to Babes¹⁵ the dark areas are to be interpreted as metachromatic granules. The bacilli are not motile."

"The spirilla found in Vincent's angina are usually somewhat longer than the fusiform bacilli and are made up of a variable number of undulations, shallow and irregular in their curvatures, unlike the more regularly steep waves of *Spirochaete pallida*. They are stained with even more difficulty than the bacilli and usually appear less distinct in the preparations. The stain, however, is taken without irregularity showing none of the apparent metachromatism observed in the bacilli." Figs. 1, 2, 3, 4.

These microorganisms when found in smears taken from the lesions of necrotic gingivitis are occasionally present almost in pure culture. As a rule, however, they are accompanied by other oral bacteria which undoubtedly flourish under these conditions. Smears usually contain the material from the surface of the lesions, and as would be expected, the difficulty of obtaining pure smears of the *Bacillus fusiformis* and Vincent's spirillum in these mixed types, is almost insuperable. That these microorganisms are the primary etiological factors in these inflammations has never been demonstrated conclusively. Because of their common association with other bacteria, it has been pointed out that they may be secondary invaders upon a background prepared for them by other bacteria. "On the other hand," as Goadby¹⁶ has stated, "the curious mass of bacteria found present in ulcero-membranous stomatitis, the tissue necrosis which is everywhere in progress, and the large number of bacteria penetrating the tissue in all directions seem difficult to dissociate from some definite rôle in the disease."

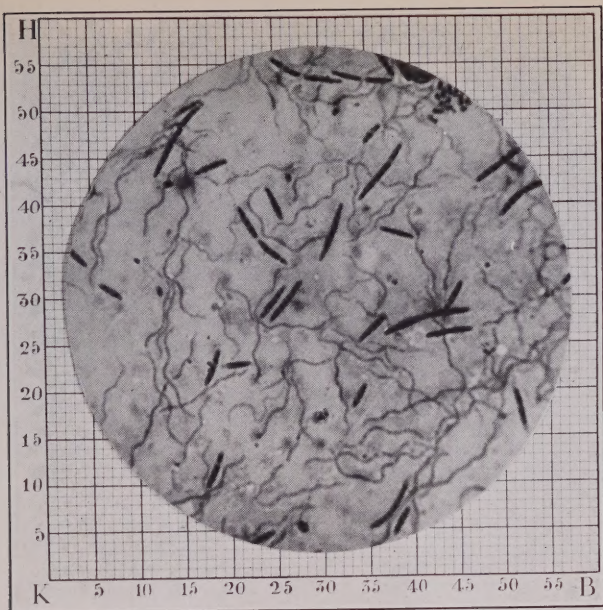


FIG. 1—X2250

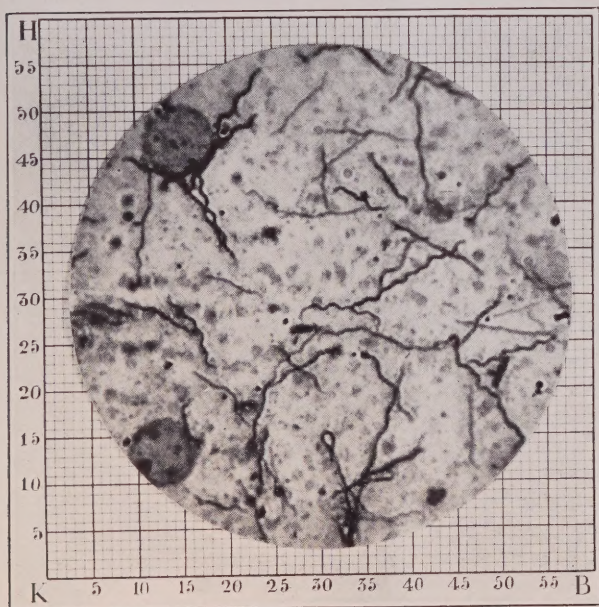


FIG. 2—X2250

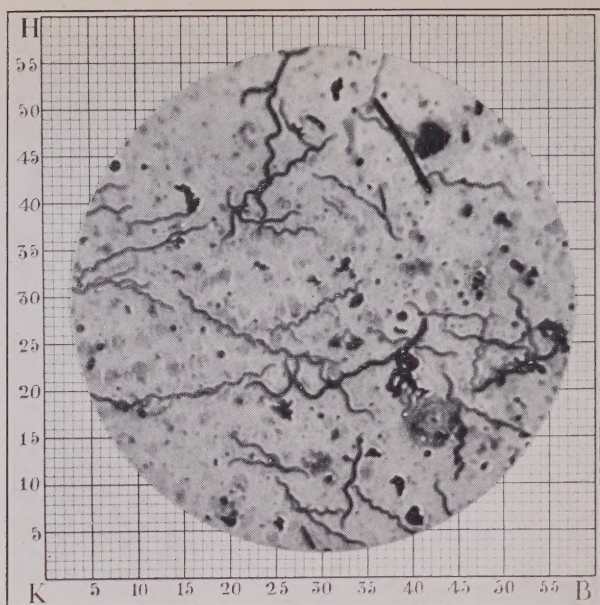


FIG. 3—X2250

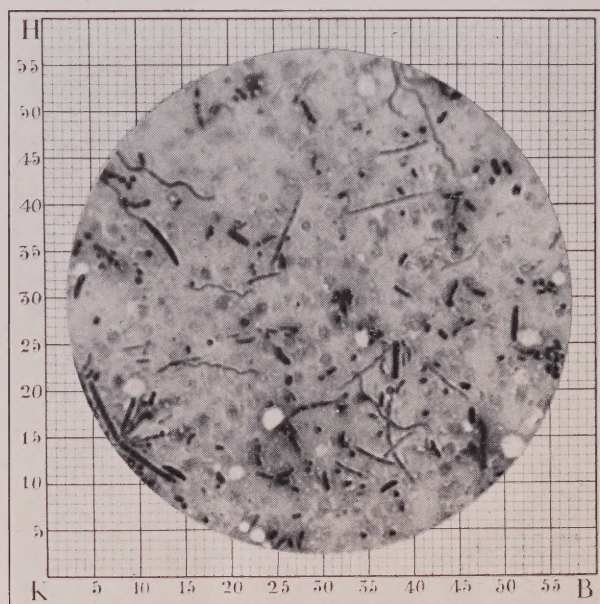


FIG. 4—X2250

These four photomicrographs were made from smears taken from four different cases of necrotic gingivitis. Note the almost pure culture of *Bacillus fusiformis* and Vincent's spirillum in Fig. 1.

This author, however, has pointed out that recent investigations on the pathogenicity of the *Bacillus fusiformis* have proved negative. The disease has not been developed in laboratory animals injected with pure cultures of the microorganism; the characteristic membranous ulceration has not been demonstrated. The findings of Mühlens and Hartmann who obtained pure cultures of the spirochæte, on inoculation of this organism, were negative. Goadby further expressed a viewpoint that "it is possible that the pathological changes associated with the presence of the organism may be due to some form of soluble toxin which has not been recognized or isolated."

(2) *Anaërobiosis*

Bacteria like all living creatures have an absolute need of oxygen, and in reference to that need may be divided into three classes:

(a) The obligatory aërobes, or those that require free oxygen for the continuance of their existence, deriving it directly from the air dissolved in the medium in which they live.

(b) The obligatory anaërobes, or those to which the presence of free oxygen is injurious, and which are capable of development in its almost complete absence. They obtain their supply of oxygen from oxygen-containing compounds.

(c) The facultative anaërobes, or those to which free oxygen is neither injurious nor essential, and which can consequently thrive either in its presence or absence. In the presence of air they behave as aërobes utilizing the oxygen directly, and in its absence they live as anaërobes.

It is the great merit of Pasteur to have shown in 1861 that certain organisms responsible for butyric acid formation in putrefaction were actually killed by oxygen. His discovery of an obligatory anaërobe brought about one of the most important changes in the biologic concepts of his time. Although his observation of this property, viz., the faculty of existing without air, was received with some scepticism, as Jordan¹⁷ has pointed out, "it has since been shown that anaërobes will grow in media where reduced hemoglobin remains unchanged and reduced methylene-blue shows no trace of reoxidation", and that "the practical absence of oxygen

is further demonstrated by the fact that strictly aërobic bacteria are not able to grow at all under these conditions."

That Pasteur¹⁸ grasped the practical conditions favouring anaërobiosis is indicated by his discussion of how his septic "vibrio" established itself in a wound. He pointed out that such a wound could be washed with aërated water containing billions of these germs without producing the least septicemia in the patient, but "let a single clot of blood or a single fragment of dead flesh lodge in a corner of the wound sheltered from the oxygen of the air, or where it remains surrounded by carbonic acid gas," then in less than twenty-four hours an infinite number of "vibrions" develop capable of causing in a very short time a mortal septicemia.

While a profuse supply of free oxygen prevents the growth of most anaërobes, nevertheless certain anaërobes develop under conditions in which small quantities of free oxygen are present. According to Chudiakow¹⁹ these are utilized in their metabolic activities. Beijerinck²⁰ has shown that the growth of *Bacillus tetani* is not inhibited by the presence in the culture media of extremely small quantities of free oxygen.

The recent statement of Fildes²¹ is of great significance. It is as follows:—"According to the view of Mansfield Clark and to obvious extensions of it, the term anaërobe as applied to a micro-organism implies that it requires for growth a certain reducing intensity in the surroundings. The absence of molecular oxygen is not the essential factor except in so far as oxygen under ordinary circumstances of growth tends to prevent the necessary degree of reducing intensity from developing. Should, however, the reducing intensity of the surroundings be great, the desired conditions may be attained even in the presence of air and growth of an anaërobe may then take place."

The mechanism of the harmful influence exercised by free oxygen upon anaërobic bacteria has been the subject of much discussion and debate. D'Herelle²² in a recent work made the following statement: "It is probable that this action is exerted upon the ferments which regulate their metabolism, all ferments being more or less sensitive to the action of oxygen. A ferment readily oxidizable cannot act, obviously, in the presence of free oxygen, as must be the case with the ferments of the strictly anaërobic bacteria. This would explain why they are unable to develop in the presence of air, or at least, why they are found

multiplying only in an environment containing reducing substances, that is, substances capable of binding oxygen."

Among the well known methods of cultivating anaërobic bacteria are the following:

(A) *Physical*

(a) The covering of the medium from which the oxygen has been removed by boiling, with a protective stratum, such as liquid paraffin, vaseline or cream.

(b) The inoculation of the medium by deep stabs in agar or gelatin, from which the oxygen has been removed by boiling, and rapidly cooled in ice water so that as little oxygen as possible is absorbed during the hardening of the medium. Agar, gelatin or oil are used to cover the medium to prevent oxygen-absorption.

(c) The mechanical displacement of air, by pumping hydrogen through an air-tight chamber containing the inoculated media.

(d) The placing of a constriction near the middle of a test-tube tends to prevent the absorption of oxygen. Further prevention may be brought about by shaping the constricted portion of the tube in the form of a coil or spiral, (Rivas.²³) The placing of a marble above the constriction, (Hall²⁴) or a tiny test-tube in the same location (Holman²⁵) intensifies the phenomenon.

(e) Certain porous, inert substances placed in the medium render it suitable for the growth of anaërobic. Glass wool, cotton wool, asbestos wool, lint, sand, a rusty nail or sterilized tissue fragments as bits of potato, meat, etc., are good examples. (Douglas, Fleming and Colebrook²⁶.)

(B) *Chemical*

(a) The removal of oxygen by the use of oxygen-absorbing chemicals, e.g., pyrogalllic acid in caustic potash, a mixture that takes up oxygen with avidity. The test-tube containing the inoculated nutrient medium is placed in a larger test-tube containing the pyrogalllic acid in caustic potash.

(b) Fresh tissue removed from animal organs (kidney, etc.) as used in growing spirochaetes in the Noguchi method. These are active reducing agents and rapidly absorb oxygen from their surroundings.

(3) *Oral Conditions Favouring Anaërobic Growth of Bacteria*

(A) *Primary Incubation Zones*

A study of the "primary incubation zones" previously cited discloses the fact that from the cultural standpoint they are ideal locations for the development and increase in virulence of anaërobes. Here the amount of free oxygen is greatly restricted, and as a rule, reducing substances are present. The many crevices, pockets, hidden localities and regions of food-impaction form the background for the growth of bacteria and complicate the pathological pictures exhibited in the mouth.

From the writer's observations the most important of the "primary incubation zones" in the development of necrotic gingivitis is the gingival flap associated with a partly or imperfectly erupted third mandibular molar. Here physical and chemical conditions that tend to anaërobiosis are usually constant. These will be discussed later at greater length. Figs. 5, 6, 7, 8.

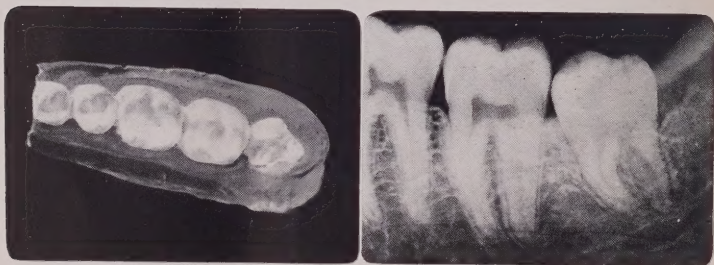


FIG. 5. MODEL AND RADIOGRAPH OF PARTLY ERUPTED LOWER RIGHT THIRD MOLAR

James²⁷, in a work on inflammatory processes connected with the third mandibular molar, pointed out that the occurrence of complications is dependent upon several factors. These he stated as follows: "The molar is practically always imperfectly erupted; the nature of the tissue in which the infection commences is of great significance; but of chief importance of all are the anatomical relations of the tooth, for besides explaining why the serious affections can occur they partly account for the two factors just mentioned."

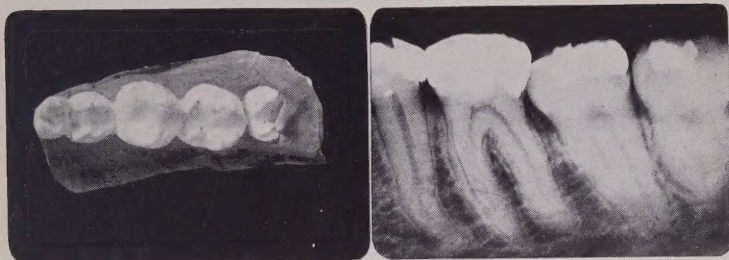


FIG. 6. MODEL AND RADIOGRAPH OF PARTLY ERUPTED LOWER RIGHT THIRD MOLAR

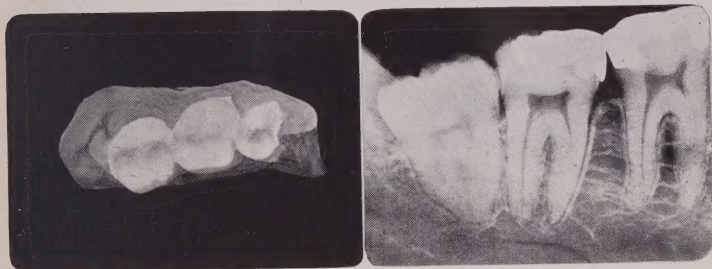


FIG. 7. MODEL AND RADIOGRAPH OF PARTLY ERUPTED LOWER LEFT THIRD MOLAR

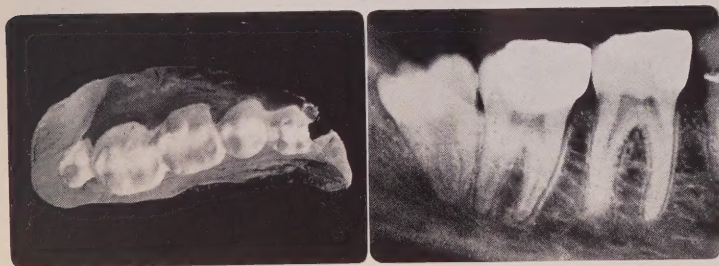


FIG. 8. MODEL AND RADIOGRAPH OF PARTLY ERUPTED LOWER LEFT THIRD MOLAR
 These illustrations show four examples of sites of "primary incubation zones" in cases of necrotic gingivitis.

In describing the anatomical relations, James stated: "The third mandibular molar is situated at the back of the oral cavity quite near to the commencement of the pharynx. In well-developed jaws the tooth is implanted in a manner similar to the other teeth having an alveolar process that is more or less subservient to it. Where the space behind the second molar is insufficient for it to take up its correct position in the dental arch, the tooth is situated almost entirely in the body of the bone. The coronoid process lies behind and to the outer side; but in cases of imperfect eruption, the tooth may be partly covered by it."

In describing the nature of the tissue, in which infection is initiated, he stated further: "The mucous membrane or muco-periosteum changes in character in the region of the third molar as it passes backwards from the dense gum, which is firmly bound down to the bone, to the lax and loosely attached tissue behind the tooth, the latter tissue much more closely resembling the mucous membrane of the pharynx with which it is continuous. The degree of eruption of the tooth more or less determines whether the surrounding muco-periosteum is mainly of the former or latter type."

In discussing the imperfect eruption of the third mandibular molar, James made the following statement of observations, which are borne out in practice: "In a large number of cases, the space is inadequate and the tooth may present very variable degrees in the stages of eruption and may be situated abnormally. The tooth is perhaps most commonly quite free of the muco-periosteum on its anterior and lingual aspects, whilst buccally and posteriorly its sides are still partially covered; or the condition may be more marked, the muco-periosteum then covering the back part of the tooth; at times the antero-internal cusp only is showing; occasionally the gum will be full although it is not perforated by the tooth. Abnormal positions are associated with imperfect eruption; the one most frequently seen is where the tooth is tipped forwards; in some cases this may occur to such a degree that the tooth is horizontal and the occlusal surface is in contact with the distal surface of the second molar. The crown of the tooth is at times tipped inwards, and this may be so marked that the buccal surface is directed upwards."

It is frequently to be noted that, when the soft tissues are found partly covering the occlusal surface, careful examination by explorer

or probe of the amelo-gingival relationship shows a separation of the soft tissues from the tooth to the extent of the enamel line on the distal surface. In other words, from the gingival margin to the enamel line, distally as a rule, organic union of the soft tissues with the tooth has been disturbed, and with separation, a pocket, film-like in thickness, is formed. In this capillary space, fluid is present.

Other extensive pockets are found associated with imperfect eruption of the mandibular third molar. Examples are frequently presented where the third molar lying in a horizontal position with its occlusal surface in apposition with the distal surface of the second molar, a deep pocket is to be found at the line of contact. Again, pouch-like pockets are often found at the distal surface of the crown, where the soft tissues, through topographic conditions, have failed to atrophy and thus reduce the crevice-depth. This was pointed out by the author²⁸ in a previous work.

The palatal margins of interproximal gingivae of upper central incisors are frequently the site of early lesions of necrotic gingivitis. Associated deep gingival crevices or pre-existing periodontal pockets furnish the basis for the establishment of the necessary "primary incubation zones". With gingival inflammation and swelling of the soft tissues, common to this region, deep thin pockets are formed which create, as in the case of the third mandibular molar, long capillary spaces containing fluid.

Capillary spaces wherever found or wherever produced, provided their base is in gingival tissue, may readily become "primary incubation zones." A common example of this is to be found where teeth are in unduly close apposition near the gingival line. This may come about through various malpositions, such as tilting of roots of adjacent teeth towards each other, the rotation of teeth whereby the teeth fail to make interproximal contact in a normal manner. This latter condition is frequently seen where there has been drifting following extraction.

Essentially the same condition of capillarity is frequently seen in the third molar region where these teeth are malposed in a buccal relation. Here the close apposition with the mucosa of the cheek induced by this malposition interferes with the free passage of cleansing oral fluids and also with the free entrance of air to the space. The contact of bridge-pontics with the mucosa and in a similar manner, the apposition of poorly fitted crown-bands create capillary spaces which serve admirably as "primary incubation zones."

(B) *Secondary Incubation Zones*

"Secondary incubation zones" may be defined as regions which are relatively unsuitable for the incubation and increase in virulence of the organisms and in which, from clinical observation, the primary planting of organisms of low virulence would not lead to disease. These areas become significant when they occur in a mouth wherein "primary incubation zones" have already become established and when the resistance of the tissue elements has been lowered by various factors. In passing, it might be noted that these secondary zones frequently present the outstanding evidence of disease in necrotic gingivitis in contra-distinction to the primary zones in which the symptoms are often less noticeable or even less acute.

The part played by traumatic occlusion in the production of "secondary incubation zones" is extremely important. The effect is that of a depression of tissue-tone which results in a lowering of resistance. Examples of this relationship are common in necrotic gingivitis, that is to say, cases are observed in which the only lesions to be found, with the exception of those located in the "primary" zones, occur where a definite traumatic occlusion can be demonstrated.

Another phase of this relationship is frequently to be seen in cases of recurrent necrotic gingivitis. Here the zone of incubation is very commonly found to be the site of an unrelieved traumatic occlusion. The importance of this finding in the treatment of both primary and recurrent cases amply warrants emphasis and even reiteration.

(C) *Factors and Conditions in Pockets and Crevices Favouring Anaërobiosis*

Certain factors are operative in pockets and crevices which determine the establishment of an anaërobic state at particular sites in them. These factors operate in many different conditions created by the various tissue changes and relationships. It is obvious therefore that those developments which tend to establish this background must have a direct bearing on the subject under discussion. The problem is a most complicated one, involving a consideration and correlation of physical, physico-chemical, and chemical principles and the conditions about the teeth and their supporting structures in which they act. The application of

physico-chemical principles has yielded a rich harvest in the field of biology and general physiology; and periodontal physiology, normal and pathologic, must also seek an explanation of its problems in terms of physics and chemistry. Natural phenomena and especially those of living organisms constantly reveal new problems of ever increasing complexity and unforeseen and closer inter-relations of these phenomena.

We must be content in a bulletin of this scope with a very brief sketch of the above-mentioned factors and conditions. The factors include the following: diffusion, solubility, viscosity, adsorption, surface tension and oxidation-reduction potential. The conditions also include the following: pocket thinness, pocket depth, changes in the soft tissue wall and pocket contents. Of the above mentioned factors, diffusion, solubility, adsorption and oxidation-reduction potential will be discussed very briefly.

Fundamental Physical Laws and Theories

Under ordinary conditions, oxygen is a colourless, odourless and tasteless gas. From a physico-chemical standpoint, the fundamental facts concerning the behaviour of gases are summed up in the following laws:—

(1) Boyle's Law, according to which, when the temperature is kept constant, the volume of a gas is inversely proportional to the pressure.

(2) Gay Lussac's (or Charles' Law), viz., the volume occupied by a given mass of gas at constant pressure is proportional to the absolute temperature. The sequel from the combination of this with Boyle's Law is: At constant volume the pressure of a gas is inversely proportional to the temperature.

(3) Gay-Lussac's Law of Volumes.—This law is purely chemical in character and deals with the relative proportions by volume in which chemical reaction between gases takes place. The law states that when two gases combine with each other to form a third gas, the volumes of the reacting gases are in a simple ratio to one another and to the volume of the gaseous product₂₉.

Two theories of the constitution of gases were evolved in an attempt to establish a common basis for the simplicity and uniformity of behaviour of gases as is shown in the foregoing three laws, viz., Avogadro's Hypothesis and the Kinetic Theory of Gases.

(1) Avogadro's Hypothesis—According to this hypothesis, equal volumes of different gases, measured at the same temperature and pressure contain the same number of ultimate particles or molecules. That is to say, that a certain volume of hydrogen contains the same number of molecules as does the same volume of oxygen or any other gas under like conditions as to pressure and temperature. This hypothesis points to a definite relationship between density and molecular weight, *i.e.*, the ratio of the densities of any two gases, *e.g.*, oxygen and hydrogen, when subjected to the same temperature and pressure, is the same as the ratio of their molecular weights. As Anderson³⁰ has pointed out, when the density of a gas is known, it is relatively easy to compute the molecular velocity required to produce the observed pressure.

(2) The Kinetic Theory of Gases:—The hypothesis of the atomic constitution of matter as stated by Poynting and Thomson³¹ is as follows: A given mass of an element contains a definite number of exactly similar indestructible particles termed atoms; these particles being exceedingly minute and exceedingly numerous in any volume which comes within the range of our senses. Each atom of a given element has a definite mass, which is always the same for the same element.

In solids, the atoms and molecules are probably agitated about some mean position, while in liquids it must be supposed that the molecules are not only agitated but are travelling about, as is seen in the phenomenon of liquid-diffusion. In a gas the molecules are much farther apart than in solids or liquids, resulting in almost complete absence of cohesion.

According to the kinetic theory of gases the molecules are in very rapid motion. Wagstaff³² has stated: "These fly about in all directions, continually encountering one another and so changing their speeds and directions. When in a confined space they impinge on the sides of the containing vessel and rebound again. The particles must be very small, their velocities great and their number per cubic centimetre enormous. A gas then cannot be at rest, it is always in violent motion and its equilibrium is dynamic equilibrium, not static."

With reference to the occurrence of oxygen, McPherson and Henderson³³ state: "Oxygen occurs in nature both as free oxygen and as a constituent of many compounds. In 100 volumes of dry air there are approximately 21 volumes of free element. In the

combined state it constitutes 88.81 per cent. by weight of water and nearly one half by weight of the common minerals such as limestone, sandstone, granite and clay which together make up the earth's crust. It is also an essential constituent of the compounds present in living organisms. For example, nearly two thirds of the human body is oxygen. The total weight of oxygen in the land, in the water, in the atmosphere, and in living organisms may be regarded as roughly equal to the united weights of all the other elements."

Factors Involved

DIFFUSION

The process of gradual dispersion or intermixture of particles of one liquid or gas among those of another is known as diffusion. The phenomena of diffusion prove that the molecules of liquids and gases are in a state of rapid motion. If the lower half of a vessel is filled with oxygen and the upper half with hydrogen and if the vessel is closed and left undisturbed, it will be found that ultimately the gas will be uniformly mixed throughout the vessel. As hydrogen is lighter than oxygen, this result cannot be due to gravity. This uniform diffusion of the gases must be ascribed to the motion of the gaseous molecules, in other words it is a molecular process. In liquids, it is an exceedingly slow process which is accounted for by the frequency with which molecules meet in collision.

The mass of gas contained in unit volume is called the concentration of that gas; the change of concentration per unit distance is called the concentration gradient. The rate of diffusion, therefore, is proportional to the concentration gradient. The ratio of the mass of gas that diffuses per second through unit area to the concentration gradient is called the coefficient of diffusion.

Philip³⁴ states: "Each gas moves from places where its concentration is high to where its concentration is low, and equilibrium is not attained until the partial pressure of each gas is the same throughout."

Two liquids capable of mixing in any proportion if left in contact and are free from the action of external forces will of themselves continue to mix until the whole mass is uniform in composition. Poynting and Thomson³⁵ state the following classic example: "This process may be illustrated by taking a vertical glass tube and

filling the lower part with a strong solution of a coloured salt such as copper sulphate. On the top of this, clear water is poured very slowly and carefully so as not to give rise to any currents in the liquid. The coloured part will at first be separated from the clear by a sharply marked surface but if the vessel is left to itself it will be found that the upper part will be coloured, the colour getting fainter towards the top while the colour in the lower part of the tube will become fainter than it was originally. This change in colour will go on until ultimately the whole of the tube is of a uniform colour. There is thus a gradual transference of the salt from the places where the solution is strong to those where it is weak and of water in the opposite direction, and equilibrium is not attained until the strength of the solution is uniform."

As Bayliss³⁶ has stated: "Substances in solution always wander from a place of higher to one of lower concentration."

Graham in 1851 conducted the first systematic experiments on diffusion. He showed that "solutions of the same strength of different substances diffused with different velocities; that solutions of the same salt of different strengths diffused with velocities proportional to the strength; that the rate of diffusion increased with the temperature and that the proportion of two salts in a mixture was altered by diffusion, and that in some cases a decomposition or separation of the constituents of complicated salts, such as bisulphate of potash and potash alum could be brought about by diffusion." (Poynting and Thomson.)

Graham's law is as follows: At equal temperature and pressures the velocities of effusion of different gases are inversely proportional to the square roots of the densities of the gases.

In 1855 Fick enunciated the law of diffusion which enables us to calculate the state of a mixture at any future time from its state at the present time. This law states that the mass of solute which diffuses through unit area in a second is proportional to the concentration gradient.

The coefficient of diffusion is defined by Edser³⁷ as the ratio of the number of gram-molecules of the solute that diffuse through a sq. cm. in a second to the concentration gradient measured in gram-molecules per cc. per cm.

SOLUBILITY

Other factors, besides gaseous diffusion are involved in the gas

exchange between an organism and the atmosphere. Gases pass into solution at some stage of the exchange, therefore the solubility of the gas in the solvent fluid determines the facilities for such an exchange. By the solubility of a gas is meant the ratio of the volume of gas dissolved to the volume of the solvent (Wagstaff).

Philip states: "The power of a liquid to dissolve a gas varies very markedly with the nature of the gas and the solubility of a given gas in a given liquid depends on the temperature and the pressure at which the absorption takes place. As regards the first of these factors it is found in almost all cases that the solubility of a gas in a liquid diminishes as the temperature rises. The relationship between the solubility of a gas and the pressure under which the absorption takes place is comparatively simple and is embodied in Henry's Law."

In 1803 Henry carefully studied the solubility of gases in liquids. His experiments led to the conclusion³⁸ "that the volume of a gas which can be absorbed by any liquid is independent of the pressure; or in other words, the mass of a gas which will dissolve in a definite quantity of liquid is directly proportional to the pressure." (The mass of a body is usually defined as the quantity of matter that it contains.)

It must be pointed out that the solubility of a gas varies markedly with its nature.

The addition of a soluble solid to a liquid decreases its power of solution unless chemical actions take place. When sugar is added to a glass of soda water, carbonic acid is thrown out of solution with the evolution of a copious stream of gas.

The velocity of the diffusion of a gas across a liquid film depends on the solubility of the gas in the liquid. Philip states: "The velocity of the diffusion depends on the power of the liquid to dissolve the gas and is as a matter of fact directly proportional to the absorption coefficient of the gas in the liquid." Exner³⁹ has shown for soap bubbles that the solubility of a gas is all-important in determining the velocity of its diffusion across a liquid film. This has also been shown by Wiesner and Molisch⁴⁰ for vegetable membranes impregnated with water.

Christoff⁴¹ found that the solubility of gases in a liquid is increased when the surface tension is lowered. The value of the absorption coefficients (volume of gas dissolved by unit volume of liquid) at 0° C. of oxygen is as follows: water, 0.04890; alcohol, 0.28397; and ether, 0.4235.

During the past year the author has had the privilege of conducting over forty different experiments on oxygen absorption and diffusion. Alkalinized glucose solutions of methylene blue as used by Hall⁴² were used, viz: (2% glucose with N/500 NaOH and 1:100,000 methylene blue) also alkalinized glucose agar with methylene blue—(agar 1% in the foregoing solution). The methylene blue is decolorized by heating in boiling water bath, recoloration takes place on exposure to the air, but protected from air it remains decolorized indefinitely. As Hall states: "In the decolorization of methylene blue, temperature is a factor; heat plays a double rôle, driving out oxygen by lowering the solubility point and accelerating the chemical reaction between alkali and organic matter."

Substances which in the absence of free oxygen are reduced to leucobases have been extensively used as criteria of anaërobiosis. Hall states that methylene blue is the most valuable chemical criterion of anaërobiosis, and the most widely advocated today, but as he points out, there are many factors apart from reduction of oxygen tension in the cultivation of anaerobes.

Methylene blue was discovered by Caro in 1877. According to Richter⁴³: "It is formed by oxidizing dimethyl-p-phenylenediamine, $\text{H}_2\text{N} \cdot \text{C}_6\text{H}_4 \cdot \text{N}(\text{C}_2\text{H}_5)_2$ with FeCl_3 in the presence of H_2S . On adding sodium chloride and zinc chloride it is precipitated as the ZnCl_2 —double salt. This is the methylene blue or fast blue found in commerce. It dyes silk with ease and also mordanted cotton. It is the most stable cotton blue. By reduction, it yields its leucobase (the HCl -salt) $\text{C}_{16}\text{H}_{19}\text{N}_3\text{S} \cdot \text{HCl}$ —tetramethyldiamidothiodiphenylamine.

Diffusion is a comparatively slow process, as is shown by the following experiment (Fig. 9). The agar content of the medium used has eliminated the convection currents which are important factors in the rapid distribution of oxygen in the decolorized alkalinized glucose solutions of methylene blue. The influence of a constriction in one of two tubes of approximately the same calibre is shown in Fig. 10. Obviously the constriction has decreased the amount of oxygen which has penetrated to the agar below it.

According to Black and Davis⁴⁴: "The explanation of the movement of convection currents is that any gas or liquid expands when heated so that a given quantity of fluid increases in volume and consequently decreases in density. In a convection current,

DEPTH OF RETURNING BLUE BAND IN DECOLORIZED METHYLENE BLUE AGAR IN
TUBES OF VARYING CALIBRES

Time	Calibre 20 mm.	Calibre 16 mm.	Calibre 11 mm.	Calibre 6 mm.	Calibre 3 mm.
24 hours	15 mm.	15 mm.	15 mm.	15 mm.	15 mm.
48 hours	17 mm.	17 mm.	17.5 m.	16 mm.	17 mm.
72 hours	19 mm.	19 mm.	20 mm.	19 mm.	19 mm.
96 hours	21 mm.	21 mm.	22 mm.	21 mm.	21 mm.
120 hours	23 mm.	23 mm.	23 mm.	22 mm.	22 mm.
11 days	26 mm.	26 mm.	27 mm.	24 mm.	27 mm.
15 days	34 mm.	34 mm.	34 mm.	32 mm.	34 mm.

FIG. 9

the lighter fluid is pushed up by the heavier surrounding fluid, just as a block of wood under water is pushed up by the surrounding water."

Diffusion is to be regarded as a molecular movement while in convection currents there is exhibited a movement in mass. The oxygen absorbed at the air-liquid interface is transferred by convection currents throughout the liquid. As in stirring, the time required for uniform mixture is greatly diminished; as much diffusion will take place in a few seconds as would take place in as many hours without the mixing, which brings many thin layers of the solvent and solute close together. The influence of convection currents on oxygen distribution in tubes of varying shapes containing alkalinized glucose solutions of methylene blue may be seen in the following simple experiment. Following decolorization by heating the tubes in a boiling water bath, they were allowed to cool in the open air with the resulting recoloration. Fig. 11.

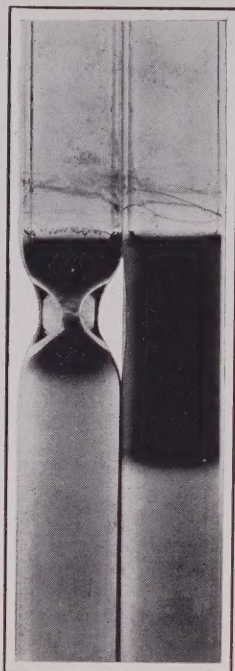


FIG. 10

Type of tube, (Calibre 5/8")	20 minutes after removal from bath.	24 hours after removal
Straight	Control blue throughout	Control blue throughout
Broad Construction	Pale blue in 5 minutes	Control blue throughout
Narrow Construction	Deep blue at bottom: fairly clear above	Control blue throughout
One inch long Narrow Construction	Deep blue at bottom: balance fairly well tinted	Control blue throughout
Two inch long Narrow Construction	Deep blue at bottom: balance well tinted	Control blue throughout

FIG. 11

The widespread use of liquid hydrocarbons as a means of excluding oxygen from culture media in anaërobic culture of bacteria is well known. After numerous experiments on this important problem Hall states: "The results with methylene blue only serve to support the conclusion that liquid hydrocarbons are to a degree superfluous and an inefficacious means of maintaining anaërobiosis;" and further that "these experiments lend little support to the use of oil as a means of anaërobiosis, and limit the technic where it is used to layering on freshly boiled oil quickly cooled nearly to 100°C. but even in this case it is less efficacious than the marble seal." And as Hall states, "the liquid oils probably permit the return of absorbed gases, but more particularly operate through convection currents which transfer gases absorbed at the air surface to the oil-medium surface."

In the writer's experiments with liquid hydrocarbons and alkalinized glucose solutions of methylene blue the findings of Hall were fully confirmed. At this point it is of great interest to note that Bayliss⁴⁵ recently made the following statement: "These various facts serve to show the futility of attempting to preserve solutions from the action of gases in the atmosphere by covering them with oil or hydrocarbons."

ADSORPTION

According to Edser⁴⁶, "in the body of a solution the molecules of the solute are distributed uniformly; but near to the surface the concentration of the solute differs from that in the interior." This is a special surface phenomenon and is termed adsorption. In positive adsorption the concentration of the solute near the surface is greater than in the interior of the solution, while in negative adsorption, the reverse is true.

It is known that the majority of substances dissolved in water lower the surface tension at the interface between the solution and a solid, or immiscible liquid, and that this is also true, with the exception of a few inorganic salts (*e.g.*, sodium chloride) at the interface between the solution and the gas. As Bayliss⁴⁷ has pointed out, "at these interfaces there is a local accumulation of free surface energy which can be altered in amount by the deposition of substances at the interface", and that "it follows then from the second law of energetics that dissolved substances which lower surface tension will be concentrated in this situation on account of the fact that free energy will be lessened thereby."

It will be recalled that according to the second law of thermodynamics or energetics, which is known also as the law of the dissipation or degradation of energy, the entropy of the universe is always striving to a maximum. This law was developed through the fundamental work of Carnot, Clausius and Kelvin. As Lewis and Randall⁴⁸ point out, "every system left to itself changes rapidly or slowly in such a way as to approach a definite final state of rest." This state of rest they have also termed the state of equilibrium, and have given the following examples of types of processes leading towards equilibrium that occur spontaneously in nature: the diffusion of material from a concentrated solution into a dilute solution toward a condition of uniform concentration; the passage of heat from a hot body to a cold, leading to uniformity of temperature; and the oxidation of organic substances by the atmosphere. This second law of thermodynamics is recognized as one of the foundations of modern science. It implies that free energy is always striving to a minimum, and, therefore, any process that lessens the free energy at an interface tends to take place. As Bayliss has stated: "Any substance in solution in a liquid, in contact with the surface of another phase will be concentrated on that surface if by so doing the free energy present there is decreased." The most stable condition of any solution, therefore, when surface tension conditions only are taken into consideration, is the one distinguished by minimum surface tension.

OXIDATION—REDUCTION POTENTIAL

Substances are "oxidising or "reducing" in so far as they possess tendencies to take up or give up electrons.

Substances vary in the strength of this tendency to take up or give up electrons and correspondingly we describe substances as weak or strong oxidising and reducing agents.

Similarly a substance which has considerable tendency to take on an electron will oxidise a substance with a lesser tendency, and this substance in turn will oxidise a further substance with a still lesser tendency to take on an electron, and we conceive different substances oxidising or reducing each other according to the relative strength of this tendency.

We speak also of strong and weak acids and we measure the relative strength of acids in terms of the readiness with which they give off hydrogen ions to the solutions in which they are dissolved.

We may, and do, measure this readiness by the hydrogen ion concentration which a given concentration of acid produces in its solution, and for convenience we use the convention of the negative logarithm of this concentration which we describe as the pH of the solution.

In an exactly analogous manner we may say that the reducing strength of a substance depends on the readiness with which it gives up negative charges of electricity, *i.e.*, electrons, to an electrode placed in contact with a solution of the substance.

The magnitude of the charge transferred under defined conditions of concentration, etc., will determine the strength of the reducing agent.

The direct method of expressing this would be to state the difference of potential in volts created between the reducing substance in solution and the electrode, just as the direct method of expressing the strength of acid is in terms of the "hydrogen potential" or the difference of potential in volts between the hydrogen electrode and the solution of the acid; but just as the most convenient method of expressing H potential is in terms of the negative logarithm of the H ion concentration so the most convenient method of expressing the reduction potential, or E_h , is as the negative logarithm of the hydrogen concentration, in atmospheres, which would give to the electrode a charge of that magnitude. This value is conventionally described as the "rH" or the reduction tendency just as we define the tendency of an acid to ionize as "pH".

Just as we describe the tendency to give off hydrogen ions in an acid as the "hydrogen potential" so we describe the tendency to give up electrons as the "reduction potential".

A substance possessing a higher reduction potential will reduce a substance possessing a lower reduction potential.

Since pH changes in healthy tissues vary within only very narrow limits due to the buffering action of substances present, so also it seems, though the evidence is incomplete, the rH of the healthy tissues is also constant within a narrow range, also owing to buffering action termed in relation to rH the "poisoning action" of tissue substances.

Finally, just as in injury or death of tissues the pH becomes less, *i.e.*, the tissue acidity increases, so in disease or death it seems the rH becomes less, *i.e.*, the reducing tendency increases.

Our conception, in a large part, of the question of biological oxidation-reduction is dependent upon the use of various organic dyes and their leuco compounds, such as methylene blue, indigo, indophenol, hydroquinone and benzidine as indicators of oxidation and reduction. As Evans⁴⁹ states: "It now appears that these compounds are representative of the limited number of organic compounds which develop reversible potentials at an inert electrode." He further states: "It follows that a series of reversible oxidation-reduction systems, such as a series of organic dyes of different reducibility, may be arranged in an electrochemical series similar to the electrochemical series of the elements. Such is the series of rH indicators elaborated by Clark and his colleagues. With the aid of these indicators it should be possible to define the apparent "hydrogen potentials" of systems which cannot themselves be studied by means of the electrode, just as the acid-base indicators are employed for the determination of the "hydrogen ion potentials." Some progress has already been attained in this direction. Thus anaërobic bacteria, suspensions of muscle cells, etc., when deprived of oxygen, develop high reduction potentials exhibited by their ability to reduce the majority of the indicators."

The recent findings of Fildes⁵⁰ on the germination of *B. tetani* are of great importance. His conclusions are as follows:—

1. On exclusion of air, culture media develop a reducing intensity which can be measured by Clark's indicators of oxidation-reduction potential.
2. The rapidity and extent of this change depend upon the constitution of the medium and the pH.
3. The period required for the germination of spores of *B. tetani* (lag) in a suitable medium at 38°C. depends mainly on the time required for this medium to reach a suitable reducing intensity.
4. Within limits, pH does not affect the lag of *B. tetani* except through its effect upon the reducing intensity of the medium.
5. The greater the reducing intensity the shorter the lag, and conversely, the slighter the reducing intensity the longer the lag until a zone of reducing intensity is reached at which germination is not observed to occur at all.
6. This zone may be measured and expressed in terms of oxidation-reduction potential (Eh). At each pH it approximates to the zone of the complete reduction of thionin, *i.e.*, at pH 7.0 it approximates to Eh +0.01 volts.

7. If spores are placed under conditions in which the Eh is more positive than this, they do not germinate.

It is obvious from the foregoing, that researches along similar lines on *B. fusiformis* and Vincent's spirillum should be undertaken, and the author suggests these problems to some enthusiastic and qualified investigator. As MacLagan⁵¹ states: "It may be emphasized that accurate work on oxidation-reduction potential in biology has only been going on for about nine years, and that much of the time has been taken up with essential chemical preliminaries. The importance of the subject cannot be doubted and it is reasonable to expect considerable advances in the near future."

The experiments of Ehrlich⁵² on oxidation in the cell point to the fact that in activity as well as asphyxia practically all cells become highly reducing, and as Bayliss⁵³ has stated, that "the reducing power of tissues depends to a large extent on their degree of activity, or in other words, of the relative rate at which oxygen is consumed and supplied." Krogh⁵⁴ states that "recently Gessler⁵⁵ (1921) has made some determinations of the metabolic oxygen consumption of small pieces of inflamed skin as compared with normal pieces from the same region," and that "he reports increases in metabolism (at 37°) of 36 to 77 per cent." It seems reasonable, therefore, that in inflammation, the reducing power of tissues is increased.

Conditions Present

It is clinically well known that the early lesions of necrotic gingivitis show a predilection for the margins of the gingivae and are not initiated as might be expected at the base or in the depths of the pockets or crevices. An explanation for the local manifestation of the infection at a site which would seem on a superficial consideration to be rather against the best conditions for anaërobic growth may be found in the actual circumstances in which the *Bacillus fusiformis* and Vincent's spirillum appear to reach their maximum reproductive activity and virulence. These circumstances are determined, in part at least, by the conditions in which the foregoing factors may operate.

POCKET THINNESS

The crevice or pocket is bounded on one side by the tooth and on the other by the soft tissues. The close relation of these walls to each other establishes a pocket resembling a flattened capillary

tube, and with its contained fluid exhibits the phenomena of capillarity. From the limited number of experiments undertaken by the author on convection currents in capillary tubes of extremely small calibre, and in films between cover-slips, and taking into account the questions of extreme pocket thinness, viscosity of pocket fluids, temperature changes, and the presence of calcific deposits which serve to interfere with great mass movements through constrictions etc., it would appear that convection currents have little bearing on the oxygen distribution in the pocket.

POCKET DEPTH

The depths of pockets associated with incubation zones vary greatly. In 356 pockets measured by Orban and Köhler⁵⁶, taking into account the factor of shrinkage, the average depth was 0.84 mm. The deepest pocket was found on the distal side of a lower third molar, the pocket depth being 5.36 mm. As referred to previously, this region is the site of the "primary incubation zone" of first importance in necrotic gingivitis.

To deviate for a moment, these pockets measured by Orban and Köhler are regarded as normal physiologic pockets, or gingival crevices, and based, as these writers state, on the "arbitrary" division of normal and pathological conditions determined by the absence or presence of ulceration. Still more recently Orban⁵⁷ stated in reference to these measurements: "The measurements were made on gingival crevices which showed no pathology, viz., formations of ulcers on the crevice epithelium." A clinical subdivision of pockets into normal and pathological, dependent on the absence or presence of suppuration only furnishes, in the author's opinion, another strong argument against the retention of the term "pyorrhea" in periodontal nomenclature and classifications of periodontal disease. And from the histo-pathological standpoint, this subdivision into normal and pathological, based on ulceration is not substantiated by the microscopic findings and is therefore unsound. James and Counsell⁵⁸ have stated in the conclusions of their excellent paper that "the presence of pus is unusual and when present is due to secondary infection, pyogenic organisms such as staphylococci being readily demonstrated in the pus." In other words, these investigators regard the pyogenic infection as an acute or subacute infection superimposed on the chronic condition. This also is the opinion of the writer as expressed in a recent paper⁵⁹.

And further, regarding ulceration, James and Counsell have stated: "Ulceration due to loss of epithelium, is certainly uncommon if it actually occurs. Histologically, the nearest approach to an ulceration is an exposed papilla of the corium and even this may be an artefact." It is of interest to note that three years earlier, the author⁶⁰ made the following statement: "When a large number of specimens are examined it is surprising how little ulcerated tissue is to be found even in the deepest pockets, or in contact with large masses of calculus."

The depth of the gingival crevice is a subject of much controversy at the present time. The great disparity of opinion is shown in the following recent statements:—

James and Counsell⁶¹: "Any depth of crevice between the epithelium and the enamel must be regarded as pathological."

Gottlieb, B.⁶²: "Frequently we find pockets of practically no depth at all. From this minimum, we find all grades of transition, up to the greatest depth without being in any way justified in drawing a line between physiologic and pathologic conditions."

Becks, Hermann⁶³: "In summarizing, it must be stated that a pocket can be considered pathologic only when the normal depth of approximately 1 mm. has been exceeded and this has been accompanied clinically by bone disturbances and inflammation. . . As soon as we find a pocket more than 1 mm. in depth below the cemento-enamel junction, we are dealing with a pathologic process."

The following mechanical agencies tend to increase the depth of the pocket:—

(a) *Calcific Deposits*—Deposits of salivary calculus frequently are formed at the border of the gingiva and as they increase in size tend to overlap the gingival crest. This may go on in a neglected case so that the distance from the outermost border of the deposit to the junction of deposit and tooth measures several millimeters. This deposit is in such close contact with the gingival tissue that only a thin film of fluid exists between them. If the pericemental attachment has been broken with the formation of a true pocket, it is necessary to consider pocket depth, from the standpoint of oxygen distribution, as being made up of the depth of the true pocket plus the distance from the orifice of this pocket to the border of the calcific deposit.

The pocket depth may be still further augmented by the presence

of nodules of calculus beneath the soft tissues. This has reference simply to the length of the capillary space through which the oxygen must diffuse to reach the base of the pocket. This is quite different from what might be called an air-line measurement as made by the probe. This latter measurement is of interest to the periodontist in arriving at a diagnosis and prognosis.

(b) Gingival and Enamel Apposition—This abnormal relationship of the gingival tissue to the enamel is particularly exemplified in cases where the gingival tissue overlaps the occlusal surface of molars, especially the first and third. With severance of the organic bond between the soft tissues and the enamel, a long thin capillary space is formed. Here the cusp inclines in their relationship to the soft tissue, as in the case of calculus formation, by introducing convolutions, provide a pocket the absolute depth of which at times is very great.

The deeper the pocket, the greater is the tendency to infection of the investing tissues. This statement is in agreement with the views of Gottlieb⁶⁴, Orban⁶⁵, and James and Counsell⁶⁶.

CHANGES IN THE SOFT TISSUE WALL

The great majority of crevices or pockets under microscopic examination show inflammatory reactions in the soft tissue wall.

James and Counsell have called attention to the changes in a site which is constant in position, occurring in the subgingival epithelium at a point immediately below the amelo-gingival angle, *i.e.*, below the junction of the subgingival epithelium with the oral epithelium. According to these investigators, the epithelial changes comprise proliferation and loss with pocket formation. In this zone of injury, the earliest pathological changes are to be noted, *viz.*, local cellular infiltration of lymphocytes and plasma cells. The lymphocytes are found in the early stages while the plasma cells are found in the later stages.

According to the recent and momentous investigations of Becks⁶⁷, "it has been demonstrated that without exception, when the epithelium of the mouth becomes fused with the enamel epithelium, and the removal of necrotic cell remnants follows, the degeneration of the enamel epithelium progresses apically and the mouth epithelium proliferates downward to cover the defect in the surface." As this investigator has shown, "if the degeneration of the enamel epithelium takes place rapidly and the mouth epithelium

for some reason does not follow to cover the defect, it is possible that a *locus minoris resistentiae* is formed which offers an entrance to infection." It would appear that this defective site described by Becks coincides with the "zone of injury" of James and Counsell.

As pointed out by the writer in a recent work⁶⁸, in periodontal or pathologic pocket formation, "the sub-epithelial connective tissue from the gingival margin to the pocket-base, and for a considerable distance beyond, presents constantly a marked cellular infiltration and in the later stages chiefly of the plasma cell type." Further in describing the superimpositions of pyogenic infections upon the primary non-suppurative inflammatory process, it was stated that "these suppurative inflammations are initiated at various sites along the pocket wall where through injury, extreme thinness or breaks, the epithelium has afforded portals of entry for pyogenic microorganisms."

POCKET CONTENTS

Substances that are commonly found in pockets are as follows:

(1) Saliva—The following table⁶⁹ shows analyses of mixed human saliva, analyses I to VI by Berzelius, Jacobowitsch, Frerichs, Tiedemann and Gmelin, Herter, and Hammerbacher respectively.

MIXED SALIVA

	I	II	III	IV	V	VI
Water.....	992.9	995.1	994.1	988.3	994.7	994.2
Total Solids.....	7.1	4.84	5.9	11.7	5.3	5.8
Suspended solids (epithelium, mucus, etc.)....	1.4	1.62	2.13			2.2
Soluble organic matter...	3.8	1.34	1.42		3.27	1.4
Potassium sulphocyanide		0.06	0.10			0.04
Inorganic salts.....	1.9	1.82	2.19		1.03	2.2

Starr⁷⁰ made observations on 610 specimens of saliva from 228 healthy normal subjects and found variations from pH 5.75 to 7.05. Of these 86% were between pH 6.35 and 6.80. Bunzell⁷¹ examined the saliva of 274 subjects. He separated his subjects according to sex and age, and obtained the following findings:

50 school boys.....	Average pH 6.64
50 school girls.....	" pH 6.62
50 female medical students.....	" pH 6.49

9 men (averaging 69 years of age) . . .	"	pH 6.24
women (averaging 74 years of age)	"	pH 6.00

As a point of interest, the saliva of several patients presenting cases diagnosed by the author as necrotic gingivitis was examined and the pH was found to range from 6.5 to 7.0.

(2) Food debris—

(3) Bacteria—

(4) Calculus—In decalcified preparations of calculus a basis of *Leptothrix buccalis* may be noted constantly. The close relationship between the activities of this organism and calculus production is shown in the experiments of Bulleid⁷². This investigator has stated: "From these experiments there seems some justification for the conclusion that the *Leptothrix buccalis* is an active agent in the production of tartar." The possibility of this relationship was first suggested by the observers Goodrich and Moseley⁷³. More recently Naeslund⁷⁴ has stated that both supragingival and subgingival calculi appear to be formed chiefly by certain microorganisms, chiefly actinomyces and leptothrix. The coarse, generally curved fibres of *Leptothrix buccalis* project radially from the tooth into the pocket making thereby a great surface development. It will be recalled that surface development is a preliminary condition for the manifestation of adsorption.

(5) Pus—According to Wells⁷⁵, it consists of the following substances:

1. The constituents of the exuded blood plasma.
2. The constituents of the leucocytes (and tissue-cells) that exist free in the pus.
3. The products of digestion of the proteins of the leucocytes and necrosed tissues.

Discussion

Gottlieb⁷⁶ has enunciated the following statement which is based on clinical observation and in the author's opinion is very significant, having a direct bearing on this problem: "It is well known that when we extract a pyorrhetic tooth, suppuration is checked at once. The inflammation was not in the tooth itself, and by extraction we have certainly not influenced the inflamed tissue or the microorganisms, yet the inflammation instantly disappears. By extraction there is only one thing which is certainly brought about and that is the destruction of the pocket. The

pocket consists of two walls, the gingiva and the surface of the tooth. By removal of the tooth, the pocket has stopped forming. From these considerations we may conclude that the presence of a pocket is the chief prerequisite for the existence of pyorrhea, the inflammation and the bacterial activity being of secondary importance."

From the foregoing brief consideration of the factors—diffusion, solubility, adsorption and oxidation-reduction potential, and the conditions in which they act, viz., pocket thinness, pocket depth, changes in the soft tissue wall and pocket contents, it seems convenient to imagine that crevices and pockets, as a rule, are ideal locations for the establishment of anaërobiosis.

In the depth of the crevice or pocket, the reducing intensity in the absence of oxygen is suitable for the growth of anaërobic micro-organisms. In the top of the crevice, the reducing intensity may be just as great but at this site oxygen is much more available. The presence of oxygen might prevent the attainment of a suitable oxidation-reduction potential for anaërobic growth by destroying reducing substances present in the pocket. In some instances the changes may be rapid and in others very slow. This depends largely upon the substances which determine the oxidation-reduction potential. If the substances are readily oxidized, the oxidation-reduction potential is raised.

If the reduction intensity can be raised in any way so that the conditions are rendered sub-optimal for the organisms, they grow with less rapidity or not at all. This can be accomplished by oxidation and for this the introduction of oxygen into the system is obviously necessary, it being assumed that an oxidase system or its equivalent is present.

In the absence of convection currents, the concentration of free oxygen at any point in the pocket is determined by:

1. The solubility of oxygen in saliva or pocket fluids. In human parotid saliva, Kulz⁷⁷ found in 100 vols. of saliva, of oxygen 1.46 vols. In submaxillary saliva of the dog, Pflüger⁷⁸ found 0.5-0.8 vols. of oxygen.

2. Diffusion constant of oxygen in pocket solution.

3. Distance from the pocket orifice.

4. Shape of the pocket; the influence of the presence of a constriction above the point has been previously illustrated. (Fig. 10)

5. Amount of oxygen used up above the point through the

processes of reduction, adsorption, etc. It has been shown previously that inflammatory processes which are highly reducing, and masses of calculus, which in all probability help to deplete the oxygen content through adsorption, are practically constant on the walls of the pocket.

In stagnation zones like "primary incubation zones" associated with the gingival flaps of partly erupted third molars, the bacteria instead of being swept away remain in situ. As Adami⁷⁹ stated, "their toxins cause necrosis of the underlying epithelium and an ulcer results, so that there is now provided a suitable medium for growth of bacteria in the damaged tissue and an entrance into the body."

In an area of necrosis there will be a drop in the oxidation-reduction potential. As Fildes⁸⁰ has stated: "The cells within this area will have consumed the local supply (of oxygen) before themselves succumbing and in the absence of renewal a permanent area of asphyxia will be established." With implantation of *B. fusiformis* and Vincent's spirillum which are putrefactive organisms, and with the proper reduction potential, these organisms will be in an environment suitable for their multiplication and activities.

HISTO-PATHOLOGY OF NECROTIC GINGIVITIS

The lesion consists essentially of an acute inflammatory process accompanied by necrosis arising on the surface and progressing more deeply with the advance of the disease.

The inflammatory process bordering the gingival surface consists of an acute polymorphonuclear infiltration scattered through the interstices of the covering epithelium and in the supporting tissues of the marginal gingiva. This acute inflammatory reaction is present both on the outer free surface as well as on its inner crevice surface. In association with this acute inflammatory reaction a necrosis and desquamation of the superficial epithelium soon follows accompanied by a marked inflammatory exudate made up largely of fibrin which incorporates the cells of the inflammatory exudate as well as the necrotic cells of the antecedent epithelium. Thus in relation to the acute inflammatory process attacking the gingival margin an ulcerating area covered by a firmly adherent pseudomembrane makes its appearance. This membrane is firmly implanted upon the ulcerating area, and sends projections of fibrin deeply into the neighbouring tissues forming the base of the ulcer.

Accompanying this ulcerating inflammatory process, bacteria are found to be incorporated in the deposit or pseudomembrane covering the surface. It is to be noted that although the inflammatory reaction is one in which the exudate is of the acute polymorphonuclear variety, there is no suppurating process with local abscess formation in the gingival tissues.

The acute inflammatory process is largely localized about the ulcerating lesion at the surface, although the influence of the bacterial attack has led to a considerable inflammatory infiltration of the deeper tissues. Furthermore, it is to be noted that the lesion is relatively localized, and does not tend to extend further than a few millimeters from the crest of the gingival margin. Nevertheless the necrosing process causes a complete destruction of the free margin, there apparently being no immunity of the tissues of either the inner or outer surface.

The inflammatory reaction which is found in the gingival tissues remote from the necrotic and ulcerating process loses the quality of an acute polymorphonuclear reaction and shows the presence mainly of an infiltration by plasma cells. There is no sharp line of demarcation between the area involved in inflammation and the healthy tissues.

There is a distinct difference between the lesion as here observed in necrotic gingivitis, and gangrenous stomatitis. In the former as we have just pointed out the line of demarcation between the advancing border of the inflammatory process and the healthy tissues is not sharply defined, while in the gangrenous stomatitis the advancing border forms a very sharply demarcated zone in which bacteria and inflammatory exudate are recognized. In this latter type of lesion an inflammatory exudate does not extend distinctly beyond the necrosing or gangrenous process. Figs. 12, 13, 14, 15, 16, 17.

TREATMENT

The case-management of necrotic gingivitis, as a rule, is divided into three main steps, as follows:

- (1) Treatment of the acute phase.
- (2) Elimination of the "secondary incubation zones".
- (3) Elimination of the "primary incubation zones".

Where the gingivitis is of the sub-acute type, the management of the average case resolves itself into the eradication of the incubation zones.

(1) TREATMENT OF THE ACUTE PHASE—This comprises the following procedures:—

(A) *Topical Application of Medicaments*

In necrotic gingivitis the local medicinal treatment best known and most widely used by Canadian dentists is the Tincture of Iodine-Silver Nitrate Combination*. In severe cases and where

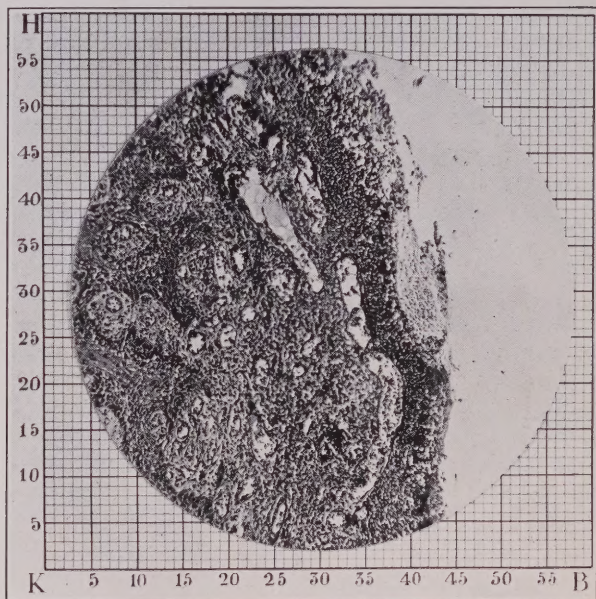


FIG. 12—X94. NECROTIC GINGIVITIS

This illustration shows a lesion near the crest of the marginal gingiva involving the crevice surface. Note the pseudomembrane and necrosis.

HK 35-KB 50—gingival crevice
HK 21-KB 43—necrosis
HK 35-KB 36—pseudomembrane

the technique outlined is strictly followed, the results as a rule are spectacular. Its peculiar affinity for necrotic tissue, the rapid shedding of the ulcerous conglomerate with restoration of a vigorous

*This method of treatment was recommended to the author some years ago by Dr. J. F. Adams of Toronto, to whom full credit is given.

epithelial covering, and the almost immediate relief from soreness and pain are attributes which make this treatment a specific for this type of infection. It has been thoroughly tested over a period of years by hundreds of dental practitioners. Among the first to apply it in the treatment of necrotic gingivitis, the author still finds it in the majority of cases the choice *par excellence*.

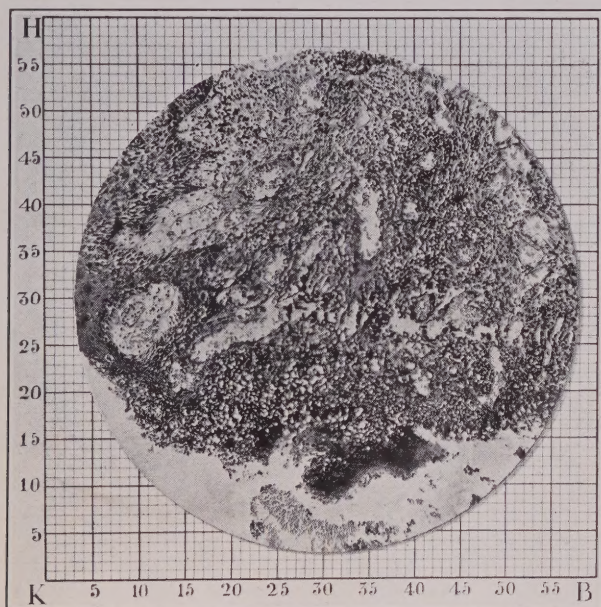


FIG. 13—X94. NECROTIC GINGIVITIS

Here again is shown a low magnification of a lesion involving the crest of the marginal gingiva. Note the acute inflammatory reaction, desquamation of the epithelium, necrosis and pseudomembrane.

HK 25-KB 44—acute inflammatory reaction

HK 20-KB 10—epithelial desquamation

HK 12-KB 30—necrosis

HK 19-KB 30—pseudomembrane

The solutions used in this combination-treatment are:—

(a) Churchill's Tincture of Iodine.

The formula is as follows:

Iodine.....	16.5 grams
Potassium Iodide.....	3.3 grams
Alcohol (70%).....	100 c.c.

All the soft tissue surfaces are freely endowed with tiny crevices and microscopic interspaces in which are present, in necrotic gingivitis, large numbers of microorganisms. Into these minute openings the iodine solution must necessarily penetrate. Churchill's tincture of iodine because of its low surface tension, rapidly flows to the gingival crevices of teeth adjacent to the point of application and readily seeps into all the microscopic irregularities.

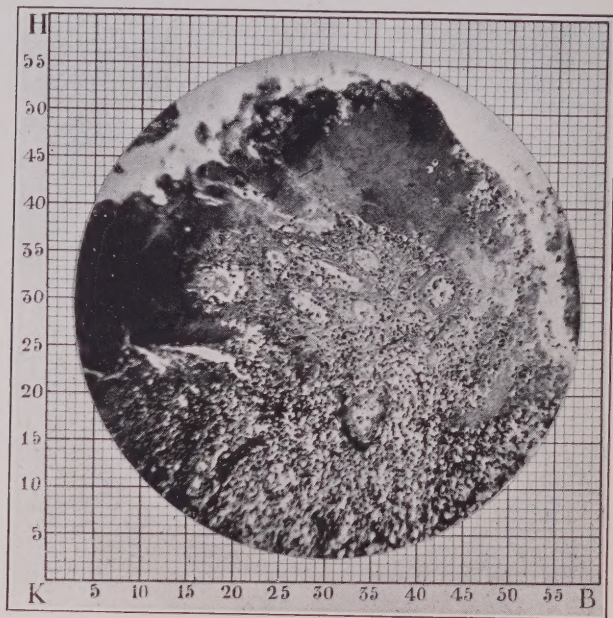


FIG. 14—X187. NECROTIC GINGIVITIS

This illustration shows a higher magnification of the necrosis and pseudomembrane.

HK 45-KB 35—necrosis

HK 35-KB 29—pseudomembrane

HK 25-KB 30—acute inflammatory reaction

(b) 35% aqueous solution of Silver Nitrate.

Steps in the topical application of the Tincture of Iodine-Silver Nitrate Combination:

(a) Place on the bracket-table two glass containers—(inverted glass castor-cups serve the purpose very well) and governed by the area of soft tissue to be treated, place on one

of them 5 to 10 pellets of cotton, match-head in size, and saturated with Churchill's tincture of iodine. On the other, 5 to 10 pellets of cotton, slightly larger than the head of a match, and saturated with 35% aqueous solution of silver nitrate are placed. The making of cotton-pellets and dipping into medicine-bottles by the operator after the treat-

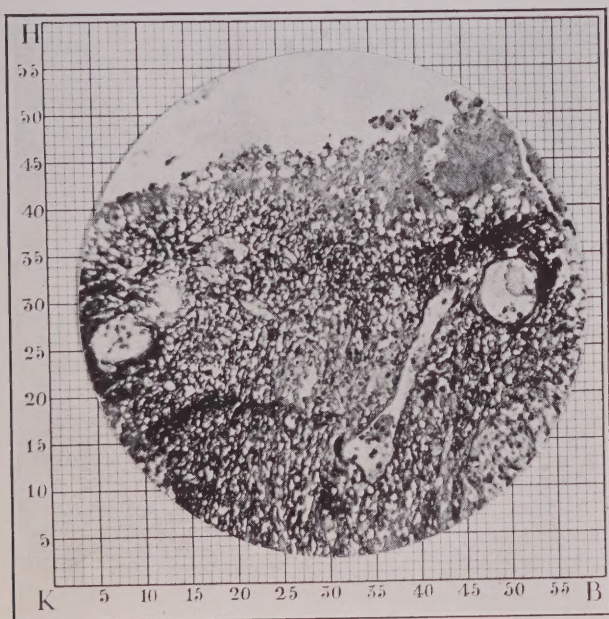


FIG. 15—X281. NECROTIC GINGIVITIS

This illustration shows the fibrin threads projecting from the pseudomembrane and attaching it to the deeper tissues.

HK 45-KB 45—necrosis

HK 35-KB 31—fibrin threads of pseudomembrane

HK 30-KB 50—dilated blood-vessel

ment has begun are impeding procedures that tend to make the consecutive application of the medicaments more difficult.

(b) Next isolate the affected area with cotton rolls, and with sterile cotton pellets gently dry the tissues, being careful not to induce bleeding. (It may be pointed out here that Adams does not advocate the drying of the tissues before the application of the medicaments.)

(c) One of the cotton pellets saturated with Churchill's tincture of iodine is taken in the pliers and lightly touched to the amelo-gingival border. With slight compression of the pellet, the liquid flows rapidly because of its low surface tension over the ulcerated tissues, along the gingival crests, into the gingival crevices and between the teeth. Care must be taken

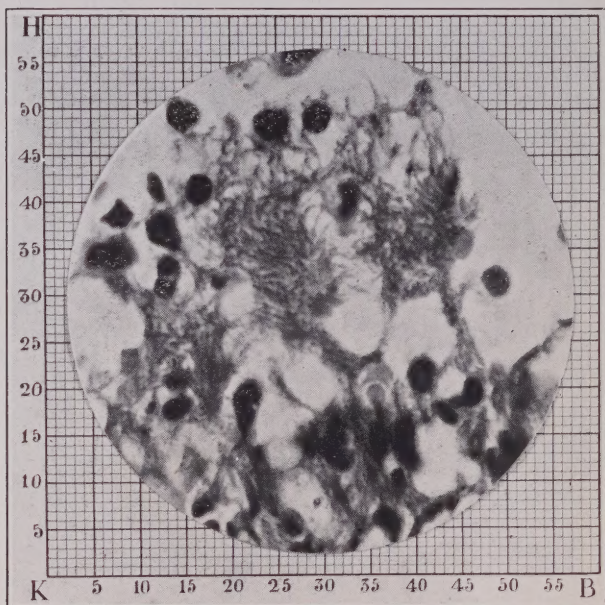


FIG. 16—X2250. NECROTIC GINGIVITIS

This photomicrograph shows the enormous masses of bacteria present in the pseudomembrane

Note also the cells of the inflammatory exudate.

HK 35-KB 25—mass of bacteria

HK 50-KB 15, 25, 30—cells of the inflammatory exudate

that the tincture is not allowed to flow over the alveolar or other oral mucosa, as it occasionally has an escharotic action. The use of small pellets of cotton, saturated but without great excess of tincture, the gentle contacting with the tissues, preceded by their careful drying, tend to limit the flow of the solution to the parts affected.

Where there has been great loss of tissue between the teeth,

frequently with marked cupping-out of the structures, and close apposition of the roots, difficulty is occasionally experienced in the placing of the tincture at the base of this inter-dental space. This is easily overcome by the use of the chip-blower. Having first removed the saliva and detritus and deposited the tincture, with a light current of air, the tincture is gently blown to the base of the space, to be followed at once with the solution of silver nitrate.

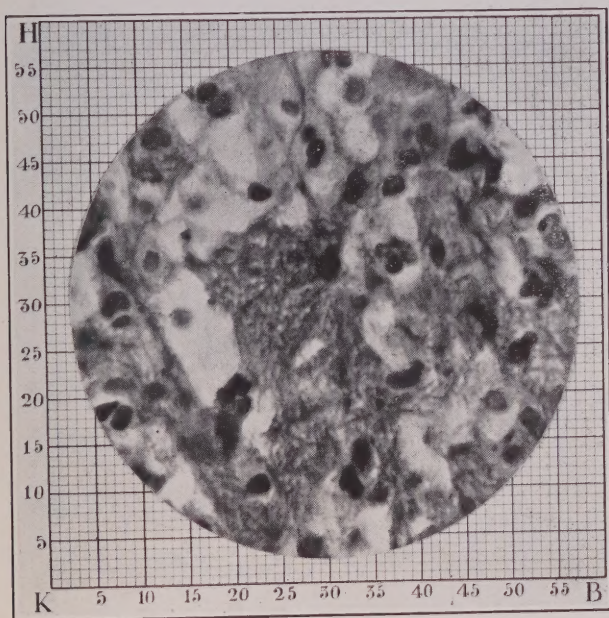


FIG. 17—X2250. NECROTIC GINGIVITIS

Here again is shown the large masses of bacteria incorporated in the adherent pseudomembrane.

HK 35-KB 25—enormous mass of bacteria in pseudomembrane

(d) A pellet saturated with the 35% solution of silver nitrate is immediately carried in the pliers to the regions holding the Churchill's tincture and gently compressed. The tiny crevices and fissures again act as sluice-ways for the silver nitrate solution, which combines with the iodine tincture resulting in the formation of a bright whitish-yellow precipi-

tate in the necrotic and ulcerated tissue. The tooth is left stainless when aqua ammonia is applied to it.

The chemical reaction between the two solutions results in the precipitation of the insoluble iodide of silver which seems to form within the necrotic tissue. This whitish film turns dark in the light and in thirty-six hours as a rule, is cast off. It seldom leaves behind a bleeding surface, all ulcerations except the large ones being

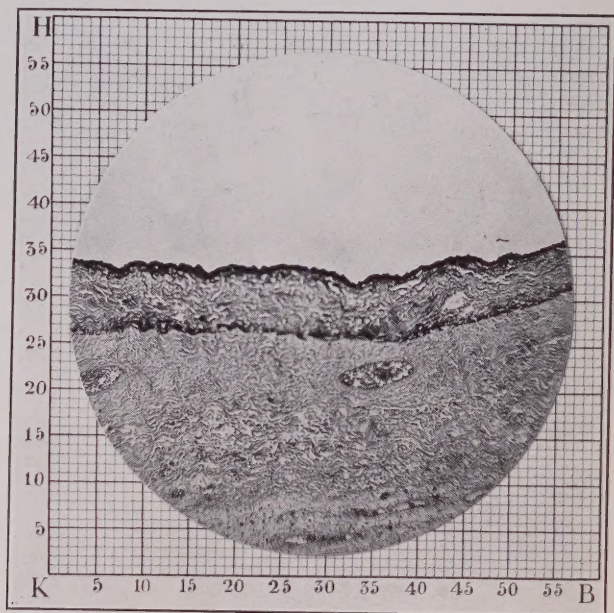


FIG. 18—X94. SILVER IODIDE PENETRATION IN SOFT TISSUE
(OVARIAN CYST.)

HK 34-KB 10—surface of soft tissue

HK 27-KB 10—depth of penetration of silver iodide

covered as a rule with new epithelium. Furthermore, the rapid reduction of the attendant gingival inflammation is a particularly striking feature.

In effect the treatment accomplishes the same result as is accomplished in the tannic acid treatment of burns. The penetration of the antiseptics not only kills the organisms but also the

superficial tissue through coagulation of the tissue proteins, and just as in the tannic acid treatment, this coagulation appears to render the dead tissue resistant to the action of the bacteria. We have in fact created a perfectly fitting sterile dressing under which a healthy epithelial growth may occur, and this indeed invariably takes place.

The penetration of the silver iodide in fresh tissue (ovarian cyst) is shown in Fig. 18. The medicaments were applied as previously described.

When the areas selected for treatment have been attended to, the writer advises the thorough irrigation of the mouth with plain warm water. At least four glasses of water are given to the patient for repeated rinsings to insure the removal of excess silver nitrate.

(B) *Instruction in Home Mouth-washing*

At the first sitting, the patient is given a prescription for a mouth wash. The agent in greatest favour at the present time is sodium perborate. Free oxygen is produced, with harmless borax. It is important that the sodium perborate be fresh, and that the mouth wash be used immediately on dissolving in warm water. Stillman and McCall⁸¹ and Burchard and Inglis⁸², advocate one teaspoonful in half a glass of tepid water. Winter and Hayes⁸³, Sorrin and Miller⁸⁴ and Hirschfeld⁸⁵ advise one teaspoonful in three-fourths of a glassful of hot water. The writer has found the latter, one teaspoonful in six ounces of warm water, to be quite efficient. It is advised that this be used at intervals of an hour for the first day or two; then five times daily until all necrotic lesions have disappeared, and three times daily, including two weeks following the dismissal of the patient.

A perborate mouth-wash that appears to be still more efficient than the plain perborate solution, and certainly more pleasant to the taste is recommended by the author. The patient is given the following prescription:—

R	Sodii perboratis.....	3	iv
	Sodii oleatis (neutral).....	5	iv
	Saccharini.....	gr.	$\frac{3}{4}$
	Ol. aurantii.....	1 ㄝ	v
	Ol. gaultheriae.....	ㄝ	xx
	Ol. menth. pip.....	ㄝ	x
	Ol. rosae.....	ㄝ	ij M.

Sig.—A teaspoonful to a glass of warm water to be used as a mouth wash as directed.

Sodium oleate is a surface tension reducent, and detergent, possessing cleansing qualities in a marked degree.

In his experiments on the relations of surface tension to bacterial phenomena, Frobisher⁸⁶ found sodium oleate to be the most useful reagent for reducing surface tension of culture media.

At the first visit, the foregoing procedures, topical application of medicaments, and instruction in home mouth-washing are carried out. Even in the most severe cases, no further treatment is indicated for forty-eight hours when at the second visit, as a rule, the patient reports a marked general improvement. The tissues present a striking picture of regeneration. With shedding of the impregnated pseudomembrane, the smaller lesions have disappeared and new epithelium now covers their sites. The area of the large lesions is, as a rule, greatly decreased. To these, on the second visit a second application of the Tincture of Iodine-Silver Nitrate Combination is made. Frequently with two applications, a great reduction and control of the acute manifestations of the disease is accomplished. However, extremely large destructive lesions, *e.g.*, those at the sites of primary incubation zones, may require a third application. It is the rule that in four days with disappearance of the necrotic lesions and general increase in gingival tone, the second step in case-management is undertaken, *viz.*, elimination of the secondary incubation zones.

When necrotic gingivitis is accompanied by the symptoms of increased temperature and pallor, the patient is advised to consult a physician.

It is emphasized that during the acute phase of necrotic gingivitis, extractions, scaling or other oral surgical procedures are contra-indicated. With the subsidence of the acute symptoms scaling may be instituted. Extractions, however, should be postponed until all signs of the disease have disappeared.

Rosenthal⁸⁷ warns against the use of general anaesthetics even in mild cases of Vincent's infection.

Before dismissing the patient at the first visit, instructions are given regarding the use of separate dishes, glasses and eating utensils. These should be boiled after using.

(2) ELIMINATION OF THE "SECONDARY INCUBATION ZONES"

It has been stated previously that frequently the lesions developed at the sites of the "secondary incubation zones" form the background of the typical clinical picture of necrotic gingivitis and stomatitis. Through the various factors which have permitted the colonization of the microorganisms in these relatively unfavourable regions, a localization at definite sites, of the characteristic lesions occurs, and which constitutes a salient feature of the disease. These factors include traumatic occlusion, gingival irritants and pocket formation. Elimination of these factors necessitates an appreciation of modern periodontal case-management. The reader is referred to some of the numerous works on the subject. The author's viewpoint, in part, may be found in a recent publication⁸⁸.

It is emphasized that in all operative procedures strict asepsis be observed. In scaling, a protective measure against the transference of microorganisms from one site in the mouth to another and which recommends itself because of its effectiveness and simplicity has been brought to the author's attention by Scherer of Houston, Texas. A small glass containing No. 7½ shot to the lower third level and an aqueous solution of mercury cyanide (1-1000) to the two thirds level is placed on the bracket-table. Between scaling procedures, the working point of the instrument is dipped into and stirred in the shot and mercuric cyanide solution, cleansing the instrument of its bacteria, blood-clot and adherent deposits, then dried with sterile gauze before continuing the scaling operation.

Where the use of a dentifrice is indicated as an adjunct to the oral hygienic measures of brushing and rinsing, the author suggests to the dental practitioner the following formula for a powder. In presenting this, it may be stated that this powder has been found to be highly efficient as a cleansing agent, beneficial in certain mild gingival inflammations, and refreshing. It may be used two or three times daily as the necessities of the case demand.

R	Calc. carb. praecip.....	3 ij
	Calc. phos. praecip.....	3 ij
	Sodii perboratis.....	3 v
	Sodii oleatis (neutral).....	3 ij
	Pulv. radidis iridis.....	3 ij
	Saccharini.....	gr. ½
	Ol. gaultheriae.....	℥ xx

Ol. rosae..... 呷 x M. Fiat pulv.
 Sig.—Use on a wet brush as directed.

(3) ELIMINATION OF THE "PRIMARY INCUBATION ZONES"

The case-management of necrotic gingivitis is obviously incomplete without the eradication of those regions known as the "primary incubation zones". It will be recalled that here through exceptionally favourable cultural conditions, the microorganisms have proliferated rapidly and increased in virulence. From these zones, the bacteria are transferred to sites of new colonization.

Recurrent attacks of necrotic gingivitis, after intermissions and frequently following treatment, are common. Almost invariably, this recrudescence may be explained by the presence in the mouth of an active and unrecognized primary incubation zone. Therefore as a prophylactic measure against reinfection, the elimination of this zone is of extreme importance.

According to the foregoing classification (p. 11), the primary zone of greatest significance is the gingival flap associated with partly or imperfectly erupted lower third molars. In many examples, the eradication of the accompanying pocket can best be accomplished through the removal of the partly erupted third molar. Due to the relation, frequently abnormal, of the tooth to its tissues, excision of the overlying gingival tissue fails to render the pocket depth into one of physiologic shallowness and further as Ito⁸⁹ has pointed out, the pulps of unerupted lower third molars frequently contain bacteria and may later become involved in the process of focal infection. He states: "If any unerupted lower third molar shows evidence of inflammation, it should be removed before serious complications arise."

Certain examples are present where with excision of the overlying gingival flap and consequent tissue contraction, the pocket is made shallow enough to permit the establishment of hygienic conditions through careful brushing. As an aid in the excision of the tissues, the author has found extremely valuable the instrument known as the "guillotine" (Hu-Friedy).

With the establishment of the diagnosis, Stillman and McCall advocate first the moderate sanitation of the mouth which may be accomplished most satisfactorily with scalers, especially those of the curette type. The emphasis here is placed on avoidance of mechanical injury to the inflamed gingival tissues. Following

this, an application of 1% aqueous solution of Acriviolet to the ulcerated areas is made. Sorrin and Miller⁹⁰ advocate a 2% solution. This is conveniently accomplished by picking up between the beaks of the cotton pliers a drop of the solution and carrying it to the gingival crevice or ulcerated surface. With the pliers in contact with the tooth or mucosa, the beaks are allowed to open with the result that the solution flows freely into or over the affected areas. In the interval between the first and second sittings, the patient is instructed to use a mouth wash of sodium perborate, a teaspoonful to $\frac{1}{2}$ glass of hot water at intervals of an hour or less frequently according to the severity of the case. This may be rendered still more effective by adding to the solution, as described, a third of a teaspoonful of the formula which follows:

Sodium Chloride.....	3	viii
Calcium Oxide.....	Grs.	L
Menthol.....	Grs.	viii
Saccharin.....	Grs.	vi

At the second sitting, the operative procedure is to carry the scaling operation a step further, or in other words making a beginning of the removal of subgingival deposits. At this time a convenient and effective means of applying the Acriviolet solution is to dip the scaler into the solution and by that means carry small amounts of it into the gingival crevice whence it spreads over the adjacent gingival tissue.

At the second or certainly at the third sitting, marked improvement is to be seen.

A brief outline of the local procedures in the order advocated by Hirschfeld⁹¹ is as follows:

First Visit—All the necrotic gingival material is removed gently and thoroughly with the cotton-wrapped end of a round tooth-pick saturated with a ten per cent. solution of neosalvarsan in glycerine. With a short twist of the tooth-pick, the slough and detritus are wiped off and the drug deposited. The patient is then directed to obtain a one pound package of sodium perborate with which to make a solution—one teaspoonful to three quarters of a glass of tepid water—to be used every half hour until otherwise instructed.

Second Visit—The topical application of the neosalvarsan is repeated. These applications are repeated daily until several days after the disappearance of the necrotic lesions.

Third Visit—The gross deposits of calculus are carefully re-

moved. The patient reduces the rinsing with the sodium perborate to intervals of one or two hours.

About ten days after the first treatment, traumatic occlusion is relieved and other local injurious agents removed. With the disappearance of the gingivitis, a proper method of tooth-brushing is instituted. The mouth wash is continued for approximately two months, twice daily, as a preventive measure against reinfection.

Canadian dentists are using, in the treatment of necrotic gingivitis, the Canadian-made Novarsan powder (914) making a ten per cent. aqueous or glycerine solution, or the already prepared Novarsan solution in water (five per cent.). It is claimed that this latter preparation has three times the factor of safety over the solution of Novarsan prepared at time of use by the dentist.

Hardgrove⁹² has worked out the following procedure which is convenient and effective. A certain amount of chromium trioxide is carried on the point of an instrument to the site of infection. The patient is then instructed to hold a mouthful of hydrogen peroxide which liberates a copious supply of nascent oxygen. A blue-black fluid is formed in the mouth as a result of the reaction between the chromium trioxide and the hydrogen peroxide. This the patient is instructed to expectorate. One to three treatments at intervals of twenty-four hours are usually sufficient to destroy all the microorganisms of the Vincent's type.

Recently, a new preparation called Mallophone has been brought to the author's attention by Hayes of New York and Mowry of Montreal. The findings of these observers would indicate that this agent is a most valuable addition to dental materia medica, and that it is destined to occupy a status of increasing prominence in periodontal therapeutics. In a somewhat limited trial, the writer has found it highly satisfactory. In its relation to the treatment of necrotic gingivitis, the following recent communication of Hayes is of special interest:

"As a result of Mallophone's specific antiseptic effect with *S. vincentii* and *B. fusiformis*, coupled with its action in encouraging healthy tissue regeneration, this new medicament has given excellent results. For this purpose a supersaturated solution of Mallophone is generously applied over the gums and the necks of the teeth with a cotton applicator and the patient is requested to refrain from expectorating for a few minutes. The patient should be advised that no ill effect will result even if some is swallowed.

These supersaturated solutions of 3 or 4% strength, are prepared by boiling three or four Mallophene Discs (each containing 0.1 gram) in 10 cc. of water.

Following this saturated solution treatment, the gingival margins with the typical necrotic dirty grayish border of gum tissue should be treated with a glycerine-Mallophene paste, working this paste well down between the teeth. This will bring about a rapid regeneration of the interdental papillae. Such paste is readily made by adding a few drops of glycerine to some of the Mallophene powder and spatulating well. (If the Mallophene powder is not handy, a crushed Mallophene Disc will be suitable.) As a result of this procedure, the patient invariably shows improvement a few hours after the first treatment. The Mallophene being healing and slightly analgesic, the irritation caused by the ordinary escharotic treatment is completely avoided. Subsequent Mallophene treatments promote healthy granulation and healing of the necrotic gum tissues and buccal mucous membranes."

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